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ACID MINE DRAINAGE ABATEMENT MEASURES FOR SELECTED AREAS WITHIN THE SUSQUEHANNA RIVER BASIN

Gannett Fleming Corddry and Carpenter, Incorporated

Prepared for:

Federal Water Pollution Control Administration

31 December 1968

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UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES FOR SELECTED AREAS WITHIN THE SUSQUEHANNA RIVER BASIN

ENGINEERING REPORT

CONTRACT NO. WA 66-21

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Engineers

1968

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UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES FOR SELECTED AREAS WITHIN THE SUSQUEHANNA RIVER BASIN

ENGINEERING REPORT
CONTRACT NO. WA 66-21

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December 31, 1968

United States Department of the Interior
Federal Water Pollution Control Administration
633 Indiana Avenue, N.W.
Washington, D. C. 20203

Gentlemen:

Re: Contract No. WA 66-21
June 29, 1966

In accordance with provisions of the above referenced Contract, we submit herein our report covering findings, conclusions and recommendations resulting from investigations and studies of acid mine drainage abatement measures for selected areas within the Susquehanna River Basin.

Very truly yours,

GANNETT FLEMING CORDDRY AND CARPENTER, INC.

A. F. Miorin
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4-14-70 [illegible]

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SECTION I --- FOREWORD

FOREWORD

In October 1961, Congress, under provisions of the Federal Water Pollution Control Act, authorized comprehensive watershed studies within major river basins throughout the nation. One purpose of these studies, currently scheduled for completion in 1971, is the development for each major river basin of a comprehensive water quality management program. In developing these water quality management programs, one of the factors required to be considered is the water pollution control facilities necessary to conserve the quality of basin waters for present and future legitimate uses. The Federal Water Pollution Control Administration is conducting investigations and studies in major river basins throughout the nation to determine, among other things, the extent of water pollution in the basins, methods for eliminating or reducing said pollution, and costs associated therewith.

One of the major river basins included in the comprehensive watershed study program is that formed by the Susquehanna River and Chesapeake Bay. A major source of pollution in this basin having a detrimental effect on water quality is the mine drainage resulting from coal mining operations in the Commonwealth of Pennsylvania. To assist in the development of a program for controlling all forms of pollution in the basin, the Federal Water Pollution Control Administration authorized the firm of Gannett Fleming Corddry and Carpenter, Inc. to conduct certain investigations and studies relative

SECTION II --- GENERAL

GENERAL

The five coal mining areas considered herein are designated for purposes of this report as Morris Run, Sheppton, Tremont, Coaldale, and Winburne. The locations of these areas are shown on Plate I (General). A glossary of terms used throughout this report is presented on Appendix A.

For purposes of presentation, the subject matter of this report has been divided into various main sections. These main sections bear the following designations:

General
Summary Of Major Findings, Conclusions And Recommendations
Morris Run Study Area - Findings, Conclusions And Recommendations
Sheppton Study Area - Findings, Conclusions And Recommendations
Tremont Study Area - Findings, Conclusions And Recommendations
Coaldale Study Area - Findings, Conclusions And Recommendations
Winburne Study Area - Findings, Conclusions And Recommendations

In each main section of the report that deals with a specific Study Area, findings, conclusions and recommendations applicable to that Study Area are presented under subsections designated as follows:

General Description
Major Subsurface Conditions Causing AMD
Major Surface Conditions Causing AMD
Water Flow Routes Into, Through, And Out Of Deep Mine Workings
MD Gauging, Sampling And Analytical Program
MD Design Volumes, Constituents And Characteristics
MD Discharges Not In Compliance With Current SWB Discharge
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AMD Abatement Plans Studied In Detail
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Discussion Of AMD Abatement Plans Studied In Detail
Recommended AMD Abatement Plan

to mine drainage pollution in the basin. These investigations and studies were performed in five designated coal mining areas located in that portion of the basin which lies in the Commonwealth of Pennsylvania. Specifically, the purpose of investigations and studies conducted by Gannett Fleming Corddry and Carpenter, Inc. was to establish for each designated coal mining area in the basin (1) the causes and extent of mine drainage, (2) the various mine drainage pollution abatement plans that are available and capable of meeting current Pennsylvania Sanitary Water Board mine drainage discharge limitations as well as costs associated therewith, and (3) an abatement plan which should be implemented. The findings, conclusions and recommendations resulting from ~~said~~ investigations and studies are set forth in this report.

GENERAL

The five coal mining areas considered herein are designated for purposes of this report as Morris Run, Sheppton, Tremont, Coaldale, and Winburne. The locations of these areas are shown on Plate I (General). A glossary of terms used throughout this report is presented on Appendix A.

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Major Subsurface Conditions Causing AMD
Major Surface Conditions Causing AMD
Water Flow Routes Into, Through, And Out Of Deep Mine Workings
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MD Design Volumes, Constituents And Characteristics
MD Discharges Not In Compliance With Current SWB Discharge Limitations
Applicable AMD Abatement Measures
AMD Abatement Plans Studied In Detail
Cost Estimates For AMD Abatement Plans Studied In Detail
Discussion Of AMD Abatement Plans Studied In Detail
Recommended AMD Abatement Plan

Various considerations bearing upon the findings, conclusions and recommendations applicable to each Study Area considered in this report are common to all Study Areas. To avoid repetition, these various considerations are discussed in this General Section. Presented in the following, under subsection headings found in all main sections of the report dealing with a specific Study Area, are considerations common to all Study Areas as well as a brief description of the topic covered in the subsection:

General Description - In this subsection, under each main section of the report dealing with a specific Study Area, there is presented general background information concerning mining, geography population, industry, etc.

Major Subsurface Conditions Causing AMD - In all Study Areas, AMD is caused by numerous natural and man-made subsurface and surface conditions. Defining these conditions, and the manner in which they are interrelated to one another, was an essential first step in determining the causes of AMD and developing Abatement Plans. Set forth in this and the following subsection for each Study Area are the major subsurface and surface conditions causing AMD. Major Study Area subsurface conditions discussed in this subsection are (1) the configuration of coal seams or veins, (2) the extent of deep mining, (3) deep mine physical features such as entries and barriers, (4) the extent of fissuring and subsidence created by deep mining, and (5) the extent of mine water pools.

Information presented in this subsection for each Study Area was obtained from aerial photographs, available mine maps, individuals knowledgeable about the Study Area, and field investigations. Aerial photographs of the Study Areas used in the preparation of this report were made available by FWPCA. Mine maps to the extent available were obtained from governmental and private sources. Coal operators and other knowledgeable individuals were contacted as an additional source of information. Field investigations and studies were made by Gannett Fleming Corddry and Carpenter, Inc. to (1) verify information and data obtained from other sources, and (2) secure additional information and data as necessary to supplement that available from other sources.

Major Surface Conditions Causing AMD - In this subsection for each Study Area, there are set forth the major surface conditions which directly, or acting in combination with various subsurface conditions, cause AMD. Surface conditions discussed in this subsection include (1) the extent of strip mining, (2) interconnections between the ground surface and deep mines created by strip mining operations, and (3) Refuse disposal. Information set forth in this subsection for each Study Area was obtained from aerial photographs, mine maps, individuals knowledgeable about the Study Area in question, and field investigations.

Water Flow Routes Into, Through And Out Of Deep Mine Workings - After establishing the major subsurface and surface conditions within a Study Area which cause AMD, water flow routes into, through and out of deep mine workings were determined. Specific points at which surface and ground waters enter into and discharge from deep mine workings had to be located before AMD Abatement Measures could be planned. Water flow routes through underground workings had to be established before estimates could be made of AMD reductions attributable to the construction of Preventive Measures. Set forth in this subsection of the report for each Study Area are the major points of interconnection between the ground surface and deep mine workings, water flow routes through the deep mine workings and discharge points therefrom.

Interconnections between the ground surface and deep mine workings considered in this subsection include (1) deep mine entries, (2) subsidence areas, (3) stream infiltration areas, (4) strip mines, (5) fissured areas, and (6) mine water pool overflows. The information presented in this subsection relative to interconnections, water flow routes and discharge points was obtained during the course of investigations and studies made to determine major subsurface and surface conditions causing AMD.

MD Gauging, Sampling and Analytical Program - MD design volumes, constituents, and characteristics developed for purposes of this report are based upon information furnished by FWPCA for each Study Area. MD information made available by FWPCA for each Study Area was obtained from a gauging, sampling and analytical program conducted by FWPCA from the summer of 1965 to the spring

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of 1967. The results of the FWPCA gauging, sampling and analytical program are set forth in this subsection of the report for each Study Area on the basis of MD discharge conditions encountered during low, average and high ground water level periods in the Study Areas.

The locations of Study Area MD discharges reported herein were noted principally during the course of the field investigations conducted by FWPCA and Gannett Fleming Corddry and Carpenter, Inc. beginning in the summer of 1965 and ending in the spring of 1967. In all probability, MD discharge points in addition to those observed during this period exist under certain weather conditions not encountered during the investigations. Findings, conclusions and recommendations contained in this report are predicated solely upon MD discharge points observed from the summer of 1965 to the spring of 1967.

Within each Study Area, FWPCA gauged, sampled and analyzed all MD discharges observed from the summer of 1965 to the spring of 1967 with the exception of those from Refuse areas. At most MD discharge points covered during this program, eight instantaneous flow measurements and grab samples were obtained. All samples collected were analyzed for, among other things, pH, iron and acidity. Because of its sporadic nature, time and personnel limitations prevented the gauging and sampling of MD discharged from Refuse areas. Although localized, short-term MD discharges having a considerable iron and acid concentration could occur from some Refuse areas, it appears that these discharges had they been included in the gauging and sampling program would not have had a significant effect on Study Area gauging and analytical results.

MD Design Volumes, Constituents and Characteristics - In addition to establishing water flow routes into, through and out of deep mine workings within a Study Area, MD discharge conditions for design purposes had to be established for each discharge point before Abatement Measures could be planned and their effectiveness estimated. Set forth in this subsection for each Study Area are the MD design volumes, constituents and characteristics used in planning and evaluating the effectiveness of Study Area Abatement Measures.

Three conditions of MD discharge were established for each Study Area to determine the necessity for Abatement Measures, design Abatement Measures, and estimate their effectiveness. The three discharge conditions are described in the following:

Design Average
Average daily MD volumes, constituents and characteristics during a year of normal precipitation;

Design Wet Weather
Average daily MD volumes, constituents and characteristics during spring high ground water level periods caused by normal precipitation from December through April;

Design Maximum
Maximum daily MD volumes, constituents and characteristics resulting from the maximum twenty-four accumulation of rainfall occurring, on the average, no more often than once every ten years.

Design Average as well as Maximum MD Volumes for each Study Area were calculated using precipitation records, estimates of surface water run-off coefficients, estimates of evaporation-transpiration losses, and other information developed during the investigations and studies. Design Wet Weather MD Volumes were calculated by adjusting, on the basis of precipitation over the period of record, MD volumes observed during that portion of the FWPCA gauging, sampling and analytical program conducted at high ground water level periods. Study Area MD constituents and characteristics for Design Average as well as Wet Weather conditions were based upon those found by the FWPCA gauging, sampling, and analytical program during periods of low and high ground water level periods respectively. Design Maximum constituents and characteristics were estimated on the basis of results obtained from the FWPCA gauging, sampling, and analytical program.

MD Discharges Not In Compliance With Present SWB Discharge Limitations -

For each Study Area, Abatement Plans were developed on the basis of bringing all MD discharges under Design Average, Wet Weather and Maximum conditions into compliance with present SWB discharge limitations. Set forth in this subsection of the report for each Study Area are the MD discharges covered by the FWPCA gauging, sampling and analytical program currently not in compliance with these limitations.

Present SWB MD discharge limitations are as follows:

pH not less than 6 nor greater than 9
Iron concentration not in excess of 7 mg/l
No acid

No additional MD discharge limitations have at this time been established by the SWB. Until such time as the degree of protection to be provided surface streams of the Commonwealth has been more fully defined by the SWB, the development of Abatement Plans on the basis of bringing all Study Area MD discharges under Design Average, Wet Weather and Maximum conditions into compliance with present SWB discharge limitations appears reasonable for preliminary planning purposes.

Applicable AMD Abatement Measures - Over the years, numerous Abatement Measures possessing the potential for eliminating or reducing AMD have been proposed for use. Before Abatement Plans could be developed for a particular Study Area, Abatement Measures applicable in light of problems and conditions peculiar to the Study Area first had to be established. Set forth in this subsection of the report for each Study Area are the Abatement Measures considered applicable in the Study Area, and subsequently used in developing Study Area Abatement Plans.

As part of investigations and studies reported herein, all known Abatement Measures considered practical without regard to the extent of previous usage were reviewed. The purpose of this review was to gather and tabulate for all known Abatement Measures pertinent information needed to determine their applicability in each of the Study Areas. A total of twenty-four Abatement Measures (eighteen Preventive, three Treatment, and three Disposal Measures) were covered by this review. Set forth on Appendix B are the twenty-four Abatement Measures reviewed, and for each, a summary of pertinent information used in determining its applicability in the various Study Areas.

AMD Abatement Plans Studied In Detail - Various Abatement Measures, separately or in combination, have the potential for eliminating MD pollution in the Study Areas. Available Abatement Measures include Preventive Measures, Treatment Measures, and Disposal Measures. All Abatement Measures applicable to a particular Study Area were reviewed separately and in combination to develop by inspection techniques alternative Abatement Plans for each Study Area. Alternative Abatement Plans developed by this procedure for each Study Area deemed of sufficient merit were subsequently studied in detail. Set forth in this subsection of the report for each Study Area is a description of the Abatement Plans studied in detail.

For Abatement Plans comprised of Preventive Measures supplemented by Treatment and/or Disposal Measures, estimates of AMD reductions attributable to the Preventive Measures were made for each Study Area on the basis of estimated improvements in run-off coefficients, volumes of surface water kept from deep mine workings, and like factors. In the preliminary design of Treatment and/or Disposal Measures forming a part of the Abatement Plans for each Study Area, due allowance was made for AMD reductions attributable to Preventive Measures.

Cost Estimates For AMD Abatement Plans Studied In Detail - For all Study Areas, various considerations associated with each Abatement Plan studied in detail were evaluated before selecting the Abatement Plan to be recommended for construction. Cost was a major one of these considerations. In establishing the Abatement Plan to be recommended for construction, project and total annual costs associated with each Abatement Plan were estimated and compared. These cost estimates are set forth in this subsection of the report for each Study Area. All cost estimates are based upon present-day price levels. Information used in preparing cost estimates for purposes of this report is set forth in Exhibit C.

Discussion of AMD Abatement Plans Studied In Detail - Various considerations including costs associated with the Abatement Plans studied in detail are discussed in this subsection of the report for each Study Area. The considerations treated are Initial and Long Term Costs, amenability to progressive construction and elimination of AMD, aesthetic benefits, etc.

Recommended Abatement Plan - Presented in this subsection of the report for each Study Area is the Abatement Plan recommended for construction and the recommended order for constructing the Abatement Measures comprising the Abatement Plan. For Abatement Plans consisting of Preventive and Treatment Measures, benefits likely to be derived from initial construction of the Preventive Measures in stages were considered in establishing the recommended order of construction. Reductions of AMD, construction quantities, as well as Initial and Long Term Costs for each Abatement Measure comprising the recommended Abatement Plan are also presented in this subsection.

APPENDIX A

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Glossary of Terms

Abatement Measure

Method by which (1) the formation of AMD is prevented or reduced, (2) AMD is treated, or (3) AMD is discharged, without benefit of treatment, in a controlled manner to surface or subsurface waters.

Abatement Plan

A single Abatement Measure, or combinations thereof, which when constructed will eliminate AMD discharges in a Study Area and/or bring said discharges into compliance with current SWB MD discharge limitations.

AMD

MD not meeting current SWB pH, iron and/or acid limitations.

Annual Fixed Costs

Amortization (30 year term) plus interest (4 per cent).

Annual Operating and Maintenance Costs

Cost attributable to labor, chemicals, power, replacements due to normal wear and tear, etc.

Collection System

Includes all facilities necessary to deliver AMD to a treatment plant or disposal site including mine water pool boreholes and pumps, flow equalization basins, conveyance sewers, and open channels.

Disposal Measure

Method by which AMD, without benefit of treatment, is discharged in a controlled manner to surface or subsurface waters; includes the Collection System.

Drift

A deep mine entry driven directly into a horizontal or near horizontal coal seam or vein where it outcrops, or is exposed at the ground surface.

FWPCA

Federal Water Pollution Control Administration.

Highwall	The exposed undisturbed strata overlying the coal being strip mined. This undisturbed strata is uphill, or in the opposite direction from the deposits of material excavated to enable removal of the coal.
Initial Costs	Project costs; first 30 year average total annual costs; either or both.
Long Term Costs	Estimated average total annual costs associated with a particular Abatement Plan over a span of years sufficient to demonstrate long term trends; 300 year period arbitrarily selected for purposes of this report; for all Study Area Abatement Plans studied in detail, long term cost projections are based upon the assumption that project costs at present day price levels will be reincurred regularly throughout the 300 year period evaluated with a frequency directly related to the replacement interval of the Abatement Measure or Measures involved.
MD	Mine drainage from either deep or strip mines.
Preventive Measure	Method by which the formation of AMD is prevented, or if not prevented, its volume, and/or pollutional characteristics reduced.
Project Cost	Includes construction contract price for physical facilities complete-in-place, purchase of lands and rights-of-way, engineering, legal and miscellaneous administrative expenses connected with construction.
Refuse	Material associated with the coal as mined but subsequently discarded. This material could consist of that separated from the coal during breaking, processing and cleaning, overburden removed during strip mining, rock removed during deep mining, etc.
Replacement Interval	The elapsed years (estimated) after which an Abatement Measure will have to be reconstructed to maintain its effectiveness.

Study Area
A geographic area wherein all precipitation falling thereon or entering therein, and becoming part of the ground water table, is relieved to surface streams from MD discharge points or from springs. The extent of a Study Area is generally defined by combinations of ground surface contours, coal outcroppings, configuration of coal seams or veins, and barrier pillars.

SWB
Sanitary Water Board of the Commonwealth of Pennsylvania.

Total Annual Costs
Annual fixed costs plus annual operating and maintenance costs.

Treatment Measure
Method by which the pollutants contained in AMD are removed to the extent necessary to meet current SWB MD discharge limitations; includes the Collection System and outfall sewer from the treatment facilities to the receiving stream. For purposes of this report, Treatment Measure also includes the conveyance of AMD originating from Refuse into strip pits communicating with deep mine workings, or depositing the Refuse in such strip pits.

Water Level Tunnel
A tunnel driven through rock from the ground surface at a grade to provide gravity flow of MD from deep mine workings.

	Place Refuse In Deep Mine Pools Or Surface Impoundments
Purpose	Reduce number of AMD discharge points, and eliminate atmospheric oxygen contact with acid producing material
General Construction Procedure	Move Refuse into deep mine or surface pools
Anticipated AMD Reduction Assuming Proper Construction And Maintenance	
Volume	None
Iron and Acid Concentration	After initial increase, a significant reduction
Extent Of Experience With Measures	
Construction	Limited
Maintenance Performed	Limited
Data Accumulated on Effectiveness	Limited
Performance Of Measures Constructed	As anticipated
Comments	Most effective when Refuse can be completely inundated

APPENDIX C

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Cost Estimating Information

I. Preventive Measures

A. Inundate Deep Mine Workings

Construction Materials and Procedure

Clean debris from opening.
Place permanent timber supports.
Construct transportation facilities.
Prepare roof, sides and pavement for placement and anchoring of the seal.
Construct seal of reinforced concrete with corrosion resistant material placed on the inside face of the seal.
Where applicable, close the opening.

Unit and/or Lump Sum Costs Used for Estimating Project Cost

Major construction contract prices:	
Seal placed at opening entrance	$1,200
Seal placed back from opening entrance -	
Clearing, shoring, and placing of timber supports at intervals of 6 feet	$25/set
Transportation of materials	$7.50/ft
Concrete seal	$250/cu yd
Engineering, legal, administrative expenses, estimating contingencies and omissions - per cent of basic construction contract price	50

Replacement

None during first 300 years

Operation and Maintenance

1% per year of initial seal project cost.

Comments

Economic loss of coal reserves, if any, not included.

B. Reconstruct Stream Channels

Construction Materials and Procedure

Purchase land for, and construct permanent access road.
Backfill and/or excavate existing channel to establish desired width and grade.
Place 6 inch crushed stone base.
Place 2 inch asphalt mat liner.

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major construction contract prices:	
Access road, including land	$0.93/ft
Excavation and/or fill	$0.80/cu yd
Crushed stone	$6.00/cu yd
Asphalt mat	$1.50/sq yd
Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	50

Replacement

Asphalt mat replaced every 30 years; initial mat project cost used for replacement cost

Operation and Maintenance

2% per year of initial mat project cost

Comments

In some instances, existing stream channel relocated in lieu of placing liner.

C. Construct Surface Water Diversion Ditches

Construction Materials and Procedure

Purchase permanent right-of-way for construction and maintenance of ditches.
Using caterpillar tractor with blade, construct ditches on uphill side of strip mines and/or subsidence areas.

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major construction contract prices:	
Right-of-way	$0.50/ft
Ditching	$0.32/ft
Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	50

Replacement

None

Operation and Maintenance

50% per year of initial ditching project cost.

D. Restore Strip Mines

Construction Materials and Procedure

Clear and grub area affected by restoration.
Backfill strip mine to within 1 foot of desired grade with available material within the Study Area compacting the fill as it is placed; fill to be graded to induce surface runoff.

Place 1 foot of compacted select fill over the area affected by restoration.
Lime, fertilize and plant area affected by restoration with appropriate grasses.

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major construction contract prices:	
Clear and grub	$200/acre
Move and place fill material (other than select material)	$0.50/cu yd
Move and place select fill material	$0.60/cu yd
Lime, fertilize and seed	$90/acre
Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	50

Replacement

Each year for the first 3 years, replace one-third of the select fill, lime, fertilizer and seed; one-third of the initial select fill, lime, fertilizer and seed project cost used for replacement cost.

Operation and Maintenance

For the first 3 years, 1% per year of the initial backfill project cost (excluding select fill).
For the first 3 years, 33-1/3% per year of the initial select fill, lime, fertilizer and seed project cost.

Comments

Where acid producing Refuse is used to meet fill requirements, the acid producing material would be placed below the ground water table where it would be continuously inundated, or sufficiently high to avoid being wetted by a fluctuating water table.

E. Move Refuse Into Strip Mines

Construction Materials and Procedure

Move and place Refuse into inactive strip mines.

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major construction contract price:	
Move and place Refuse	$0.50/cu yd
Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	50
Replacement	None
Operation and Maintenance	None

F. Excavate And Restore Subsidence Areas

Construction Materials and Procedure

Clear and grub affected area.
Scalp and store topsoil.
Excavate to stable subgrade.
Backfill to within 1 foot of desired grade with available material within the Study Area compacting the fill as it is placed; fill to be graded to induce surface runoff.
Replace and compact topsoil over the affected area.
Lime, fertilize and plant affected area with appropriate grasses.

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major construction contract prices:	
Clear and grub	$400/acre
Excavate, move and place fill material	$0.50/cu yd
Lime, fertilize and seed	$90/acre

Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	50

Replacement

Each year for the first 3 years, replace one-third of the topsoil, lime, fertilizer and seed; one-third of the initial topsoil, lime, fertilizer and seed project cost used for replacement cost.

Operation and Maintenance

For the first 3 years, 1% per year of the initial excavation and backfill project cost (excluding topsoil).

For the first 3 years, 33-1/3% per year of the initial topsoil, lime, fertilizer and seed project cost.

Comments

In some instances, only backfilling and restoration will be required.

G. Construct Impermeable Seal On Ground Surface

Construction Materials and Procedure

Clear and grub as necessary.
Restore stream channels, excavate and backfill subsidence areas, move Refuse material, backfill strip mines, etc. to accommodate construction of the impermeable seal.
Place 2 inch asphalt mat liner.

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major construction contract prices:

Clear and grub	$400/acre
Earthmoving	$0.50/cu yd
Asphalt mat	$1.50/sq yd

Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	50

Replacement

Asphalt mat replaced every 150 years; initial asphalt mat project cost used for replacement cost.

Operation and Maintenance

0.7% per year of initial asphalt mat project cost.

Comments

Cost of land acquisition and/or damage not included.

H. Construct Impermeable Seal Below Ground Surface

Construction Materials and Procedure

Clear and grub as necessary.
Scalp and store top 4 feet of overburden.
Grade and prepare affected area to induce surface runoff.
Place 2-1/2 pounds of bentonite per square foot over affected area.
Replace and compact overburden.
Lime, fertilize and plant affected area with appropriate grasses.

Unit and/or Lump Sum Costs

Major construction contract prices;

Clear and grub	$400/acre
Excavate, move and replace overburden	$0.50/cu yd
Furnish and place bentonite	$0.06/sq ft
Lime, fertilize and seed	$90/acre

Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	50

Replacement

Each year for the first 3 years replace one-third of the top foot of cover, lime, fertilizer and seed; one-third of the initial project cost for the top foot of cover, lime, fertilizer and seed used for replacement cost.

Operation and Maintenance

For the first 3 years, 1% per year of the initial earthmoving project cost.

For the first 3 years, 33-1/3% per year of the initial project cost for the top foot of cover, lime, fertilizer and seed.

II. Treatment Measures

A. Collection System

1. Boreholes and Deep Well Pumps

Construction Materials and Procedure

Purchase land for permanent access road and pumping site.
Construct permanent access road.
Install electric lines to pumping site.
Drill and prepare 2 boreholes into deep mine workings, install acid proof casing for entire depth of borehole, prepare foundation and structural supports for pumps and motors.
Install acid resistant pump, column and shaft, and motor at each borehole.
Construct transition structure from pumps to conveyance sewer.
Install fence around pumping site.

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major construction contract prices:	
Pumping site land	$500/acre
Access road, including land	$0.93/ft
Drill borehole and install corrosion resistant casing (assumed 24 inch borehole in all cases)	$138/ft
Foundation and structural supports for pumps and motors	$30,000/site
Furnish and install corrosion resistant pumps, columns and shafts, motors, and voltage starters; pump capacities range from 100 to 5,650 gpm, total dynamic heads from 30 to 180 feet; construction contract prices range from $20,000 to $40,500	
Motor and pump controls	$6,000/site
Transition structure	$5,000/site
Fencing	$5.50/ft
Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	20

Replacement

Pumps, columns and shafts, motors, and voltage starters, foundation and structural support replaced every 30 years, transition structures every 60 years; initial project cost for these items used for replacement cost

Operation and Maintenance

5% per year of initial fence and access road project cost.
3% per year of initial pump, column and shaft, motor, and voltage starter project cost.
$0.02/kilowatt hour based on design average conditions.

Comments

Design wet weather volumes used for sizing pumps.

2. Flow Equalization Basins

Construction Materials and Procedures

Purchase land for permanent access road and basin.
Construct permanent access road.
Install electric lines to metering device.
Construct basin.
  a. Clear and grub
  b. Perform earthwork for shaping basin (assumed suitable material for fill available within the Study Area); all fill to be compacted
  c. Basin walls to have top width sufficient to accommodate trucks
  d. Construct inlet and outlet structures; outlet structure to contain rate-of-flow control and metering devices
  e. Construct overflow structure; place protective coating on exposed surfaces
  f. Place 4.4 pounds of bentonite per square foot over the wetted area; mix in top 2 inches
  g. Construct basin bypass
  h. Lime, fertilize and plant with appropriate grasses all inner slopes above maximum liquid level, and all outer slopes
Construct surface water diversion ditches on uphill side of basin
Install fence around basin

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major construction contract prices:

Basin site land	$500/acre
Access road, including land	$0.93/ft
Clear and grub	$400/acre
Earthmoving and placing	$0.50/cu yd
Ditching	$0.32/ft

Outlet structure; rate-of-flow control device capacities range from 50 to 10,300 gpm, construction contract prices from $10,000 to $35,000	
Reinforced concrete	$100/cu yd
Furnish and place bentonite	$0.19/sq ft
Lime, fertilize and seed	$90/acre
Fencing	$5.50/ft
Engineering, legal and administrative expenses, estimating contingencies and omissions - per cent of basic construction contract price	20

Replacement

Outlet structure and equipment replaced every 30 years, overflow structure concrete replaced every 90 years; initial project cost for these items used for replacement cost

Operation and Maintenance

5% per year of initial project cost for access road, earthmoving, and furnishing and placing bentonite
2% per year of initial outlet structure and fencing project cost

Comments

Design maximum volumes used for sizing basins

3. Conveyance Sewers

Construction Materials and Procedure

Purchase permanent right-of-way for sewers
Excavate trench, place vitrified clay sewer, backfill
Construct manholes at 1,000 foot intervals and at changes in direction and grade
Where applicable, construct transition structure from MD discharge point to conveyance sewer

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major Construction contract prices:	
Right-of-way	$0.50/ft
Excavate, furnish and install sewer, and backfill; sewers range from 6 to 36 inches in diameter, construction contract price from $7.55 to $55 per foot (assumed 15% rock)	
Transition structure	$5,000
Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	20

Replacement

Sewers replaced every 90 years, transition structures every 60 years; initial project cost less rights-of-way used for sewer replacement cost, initial transition structure project cost used for replacement cost

Operation and Maintenance

1% per year of initial project cost, less rights-of-way

Comments

Design wet weather volumes used for sizing conveyance sewers

4. Open Channels

Construction Materials and Procedure

Purchase right-of-way for open channels
Excavate to proper channel dimension and grade
Place 6 inch crushed stone base
Place 2 inch asphalt mat liner
Where applicable, construct transition structure from MD discharge points to open channel

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major construction contract prices:

Right-of-way	$0.50/ft
Excavation and/or fill	$0.80/cu yd
Crushed stone	$6.00/cu yd
Asphalt mat	$1.50/sq yd
Transition structure	$5,000
Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	20

Replacement

Asphalt mat replaced every 30 years, transition structures every 60 years; initial project cost for these items used for replacement cost

Operation and Maintenance

2% per year of initial mat project cost

Comments

In the Winburne Study Area, land for construction of open channels would be purchased, and fencing installed along entire length of open channel system; design maximum volumes used for sizing open channels. Design wet weather volumes used for sizing open channels in other Study Areas

B. Treatment Facilities - Chemical Neutralization, Oxidation, and Precipitation

Construction Materials and Procedure

Purchase land for plant site and access road
Construct permanent access road
Prepare site including installation of electric lines
Construct treatment plant

- a. Control building
  Concrete block superstructure with brick facing; contains wet well, untreated AMD pumps, equipment controls, laboratory, sludge vacuum filters
- b. Oxidation - flocculation tanks
  Concrete construction
- c. Clarifier - thickener tanks
  Concrete construction
- d. Sludge holding tank
  Concrete construction
- e. Interunit piping
  Lined cast iron
- f. Outfall sewer to receiving stream

Install fence around site

Unit and/or Lump Sum Costs Used For Estimating Project Cost

Major construction contract prices:

Complete treatment facilities including land, access road, site preparation and fencing; plants range in size from 4.35 to 14.9 mgd, construction contract prices from $214,000 to $1,050,000

Engineering, legal and administrative expenses, and estimating contingencies and omissions - per cent of basic construction contract price	20

Replacement

Treatment facilities replaced every 30 years; initial project cost used for replacement (1)

Operation and Maintenance

Based on design average conditions; yearly supervision and labor costs vary from $53,000 to $71,000; yearly power ($0.02 per kilowatt hour) costs from $6,000 to $31,500; yearly chemical costs from $7,000 to $194,000; yearly maintenance and miscellaneous costs from $7,500 to $31,000

Engineering, administrative and other expenses, and estimating contingencies and omissions - per cent of basic operating and maintenance cost	10

Comments

Design wet weather conditions used for sizing treatment plant; assumed sludge cake would be disposed of in Study Area strip pits

(1) Except for Sheppton Study Area where the effect of decreasing concentration was taken into consideration

SECTION III --- SUMMARY

SUMMARY

Major findings, conclusions, and recommendations resulting from investigations and studies reported herein are summarized in the following:

1. The five Study Areas covered by this report range in size from 4.6 to 13.5 square miles All are sparsely populated and, with the exception of mining to various degrees in all Study Areas, presently have little, if any, commercial or industrial activity of consequence.

2. Major coal mining operations have, for all practical purposes, been discontinued in the Study Areas Present strip mining operations in the Morris Run Study Area are likely to continue for some time into the foreseeable future; mining operations in other Study Areas are likely to be curtailed.

3. For all practical purposes, no major use is presently made of streams within the Study Areas Unless the Study Areas and surrounding locales experience extensive future development of one type or another, extensive future use of streams within the Study Areas does not appear too likely even if AMD pollution of streams in the Study Areas is eliminated.

4. With the exception of the Morris Run Study Area, the receiving stream outside of the Study Area into which all Study Area AMD

is eventually discharged also receives AMD from sources upstream and downstream from the Study Area.

5. In all Study Areas, AMD is caused by numerous natural and man-made subsurface and surface conditions. Defining these conditions and the manner in which they are interrelated was an essential first step in developing AMD Abatement Plans for the Study Areas.

6. In all Study Areas, water flow routes into, through, and out of the mine workings are many and varied. To develop AMD Abatement Plans for the Study Areas, it was essential that these flow routes be determined. Specific points at which surface and ground waters enter into and discharge from the mine workings had to be located; water flow routes through the workings had to be established.

7. In addition to specific points of connection between the ground surface and deep mine workings through which surface and ground waters gain entry to the workings, surface and ground waters also gain access to deep mine workings in the Morris Run and Winburne Study Areas through an extensively fissured overburden caused by extensive deep mining in close proximity to the ground surface. Some fissuring of the overburden is evident in the Sheppton and Tremont Study Areas. Very little, if any, is evident in the Coaldale Study Area.

8. Excluding Refuse areas a total of sixty-four MD discharges ranging from four located in the Sheppton Study Area to twenty-four in the Coaldale Study Area were observed during the course of investigations and studies reported herein. Compared to other AMD discharges, it appears that MD discharges from Refuse areas are not of major significance in any of the Study Areas.

9. In all probability, MD discharge points, in addition to those found in the Study Areas during the course of investigations and studies reported herein, exist during certain weather conditions. Conclusions and recommendations contained herein are based solely upon the MD discharge points observed during the investigations and studies

10. Improving the quality of MD discharges in all Study Areas as needed to insure compliance with current SWB MD discharge limitations served as the objective for all Abatement Plans developed for purposes of this report. Current SWB MD discharge limitations are as follows:

pH not less than 6 nor greater than 9
Iron concentration not in excess of 7 mg/l
No acid

11. None of the sixty-four MD discharges found in the Study Areas during the course of investigations and studies reported herein appeared consistently to meet current SWB MD discharge limitations. Therefore, all MD discharges found during the investigations and studies were included in Abatement Plans developed

for purposes of this report.

12. For purposes of developing Abatement Plans, design values had to be established for the volumes, constituents, and characteristics of MD discharges in each Study Area. These design values for combined MD discharges in each Study Area are summarized in the following:

	Design Average	Design Wet Weather	Design Maximum
Morris Run Study Area			
Volume - mgd	10.5	22.2	384
pH	3.0	3.0	3.0
Total iron - mg/l	80	60	30
Acid (as $CaCO_3$) - mg/l	690	510	320
Sheppton Study Area			
Volume - mgd	13.6	21.2	432
pH	3.9	3.9	3.9
Total iron - mg/l	1.2	0.7	0.3
Acid (as $CaCO_3$) - mg/l	80	55	30
Tremont Study Area			
Volume - mgd	8.4	11.1	289
pH	3.4	3.5	3.5
Total iron - mg/l	35	30	20
Acid (as $CaCO_3$) - mg/l	150	130	105
Coaldale Study Area			
Volume - mgd	3.5	5.4	78
pH	3.0	3.0	3.0
Total iron - mg/l	25	15	10
Acid (as $CaCO_3$) - mg/l	270	215	125
Winburne Study Area			
Volume - mgd	6.2	14.9	204
pH	2.9	2.9	2.9
Total iron - mg/l	205	160	95
Acid (as $CaCO_3$) - mg/l	940	815	615

13. As part of the investigations and studies reported herein for each Study Area, all known AMD Abatement Measures considered practical (twenty-four in number) were reviewed to determine their applicability for reducing or eliminating AMD in light of problems and conditions peculiar to the Study Area. Nine of these Abatement Measures were determined to be applicable in one or more of the Study Areas and were subsequently used singularly and/or in combination in developing Abatement Plans for the Study Areas. A listing of these AMD Abatement Measures is set forth in the following:

I. Preventive Measures:

Inundate Deep Mine Workings
Reconstruct Stream Channels
Construct Surface Water Diversion Ditches
Restore Strip Mines
Move Refuse Into Strip Mines
Excavate And Restore Subsidence Areas
Construct Impermeable Seal On Ground Surface
Construct Impermeable Seal Below Ground Surface

II. Treatment Measures:

Chemically Neutralize, Oxidize, and Settle In Treatment Facilities

14. With the exception of the Sheppton Study Area, the Project Cost for Abatement Plans comprised only of Treatment Measures was found to be less than the Project Cost for all other Abatement

Plans studied in detail. In the Sheppton Study Area, the Project Cost for Abatement Plans comprised only of Treatment Measures was found to be greater than Abatement Plans comprised of both Preventive and Treatment Measures because Treatment Measures had to be designed for Catawissa Creek flows in addition to AMD originating within the Study Area.

15. With the exception of the Sheppton Study Area, the Project Cost for Abatement Plans comprised of both Preventive and Treatment Measures was found to fall between the Project Costs for those Abatement Plans comprised solely of Treatment Measures and those comprised solely of Preventive Measures.

16. In all Study Areas, the Project Cost for Abatement Plans comprised solely of Preventive Measures was found to be considerably greater than the Project Cost for other type Abatement Plans.

17. In all Study Areas, the Long Term Cost for Abatement Plans comprised only of Treatment Measures was found to be less than the Long Term Cost for Abatement Plans comprised solely of Preventive Measures.

18. In all Study Areas, the Long Term Cost for Abatement Plans combining both Preventive and Treatment Measures was found to be less than the Long Term Costs for Abatement Plans comprised solely of Preventive Measures and Abatement Plans comprised solely of Treatment Measures.

19. For Study Area Abatement Plans developed for purposes of this report comprised of both Preventive and Treatment Measures, estimated AMD reductions attributable solely to Preventive Measures vary from one to eighty per cent on the basis of Design Average discharge conditions. In the Sheppton Study Area, most of the estimated eighty per cent AMD reduction is attributable to reconstruction of the Catawissa Creek stream channel. This Preventive Measure, for all practical purposes, accomplishes nothing more than the conveyance of AMD from upstream sources through the Sheppton Study Area. Exclusive of the Sheppton Study Area, maximum AMD reductions attributable to Preventive Measures in other Study Areas are estimated at approximately fifty per cent.

20. For Study Area Abatement Plans developed for purposes of this report comprised of both Preventive and Treatment Measures, Project Costs for Preventive Measures, for the most part, are equal to or less than Project Costs for the Treatment Measures involved.

21. For Study Area Abatement Plans developed for purposes of this report comprised of both Preventive and Treatment Measures, Long Term Costs for the Preventive Measures involved appear considerably less than the Long Term Cost for the Treatment Measures; the cost of Preventive Measures per ton of acid removed also appear considerably less than that for the Treatment Measures.

22. The Project Costs of the Collection System required as a part of the Treatment Measures included in the various Abatement Plans developed for purposes of this report range from an estimated fifty to eighty-two per cent of Treatment Measure Project Costs.

23. Investigations and studies reported herein indicate that the only Preventive Measure capable of completely eliminating AMD in the Study Areas is the construction of an impermeable seal on the ground surface of the Study Areas.

24. In all Study Areas, the Abatement Plan recommended for construction includes a combination of both Preventive and Treatment Measures.

25. Abatement Plans recommended for the Study Areas comprised of both Preventive and Treatment Measures possess the following advantages:

a. Long Term Costs associated with such Abatement Plans are less than for other type Abatement Plans.

b. Preventive Measures comprising a portion of such Abatement Plans may be more readily financed and constructed in stages.

c. Subsequent to the construction of each Preventive Measure included in such Abatement Plans, its effectiveness can be evaluated and the information obtained therefrom used to advantage in planning the next Abatement Measure.

d. For a given sum of money made available to abate AMD pollution, more of such type Abatement Plans can be initiated and a broader program of AMD pollution abatement developed.

e. After all applicable and economically justifiable Preventive Measures included in such Abatement Plans have been constructed, Treatment Measures may subsequently be provided to insure compliance with then existing SWB MD discharge limitations.

26. Presented in the following is a summary of pertinent Project Cost information for the Abatement Plan recommended for construction in each Study Area.

	Estimated Project Costs
Morris Run	
Preventive Measures	$3,750,000
Treatment Measures	3,019,000
Total	$6,769,000
Sheppton	
Preventive Measures	$ 372,600
Treatment Measures	1,583,000
Total	$1,955,600
Tremont	
Preventive Measures	$ 528,600
Treatment Measures	1,771,200
Total	$2,299,800
Coaldale	
Preventive Measures	$ 411,500
Treatment Measures	2,175,000
Total	$2,586,500
Winburne	
Preventive Measures	$2,872,000
Treatment Measures	2,742,000
Total	$5,614,000

27. Presented in the following is a summary of pertinent Annual Cost information covering the Abatement Plan recommended for construction in each Study Area.

I. Average Over Initial Thirty Years

	Estimated Annual Costs		
	Total	Per Ton Acid Removed	Per Acre Study Area
Morris Run			
Preventive Measures	$240,000	$ 95	$ 28
Treatment Measures	501,200	[illegible]	58
Total	$741,200	$ 67	$ 86
Sheppton			
Preventive Measures	$ 23,150	$ 20	$ 8
Treatment Measures	233,400	492	79
Total	$256,550	$160	$ 87
Tremont			
Preventive Measures	$ 40,250	$ 98	$ 9
Treatment Measures	285,400	180	67
Total	$325,650	$162	$ 76
Coaldale			
Preventive Measures	$ 26,770	$104	$ 3
Treatment Measures	264,200	226	34
Total	$290,970	$204	$ 37
Winburne			
Preventive Measures	$198,700	$116	$ 51
Treatment Measures	463,600	64	119
Total	$662,300	$ 74	$170

II. Average Over Three Hundred Years

	Estimated Annual Costs		
	Total	Per Ton Acid Removed	Per Acre Study Area
Morris Run			
Preventive Measures	$ 34,900	$ 14	$ 4
Treatment Measures	420,400	49	49
Total	$455,300	$ 41	$ 53
Sheppton			
Preventive Measures	$ 5,150	$ 5	$ 2
Treatment Measures	148,100	312	50
Total	$153,250	$ 95	$ 52

	Estimated Annual Costs		
	Total	Per Ton Acid Removed	Per Acre Study Area
Tremont			
Preventive Measures	$ 18,600	$ 45	$ 4
Treatment Measures	207,100	149	48
Total	$225,700	$126	$ 52
Coaldale			
Preventive Measures	$ 5,600	$ 22	$ 1
Treatment Measures	207,400	178	26
Total	$213,000	$150	$ 27
Winburne			
Preventive Measures	$ 23,600	$ 14	$ 6
Treatment Measures	398,000	54	102
Total	$421,600	$ 47	$108

28. Treatment Measures included as a part of Abatement Plans recommended for each Study Area are comprised of (a) facilities required to collect and convey AMD to AMD treatment facilities and (b) treatment facilities for the chemical neutralization, oxidation, and sedimentation of AMD. Preventive Measures recommended for each of the Study Areas are described in the following:

Morris Run
a. Reconstruct stream channels in all stream infiltration areas.
b. Excavate and restore all major subsidence areas.
c. Construct surface water diversion ditches at certain selected strip mines.
d. Restore certain selected strip mines.

Sheppton
a. Reconstruct Catawissa Creek stream channel.
b. Inundate deep mine workings

Tremont
a. Divert Gebhard Run and reconstruct stream channel in one major stream infiltration area.
b. Reconstruct stream channels in all other stream infiltration areas.

c. Construct surface water diversion ditches at certain selected strip mines.

Coaldale

a. Reconstruct stream channels in all stream infiltration areas and at AMD pool overflows.
b. Restore certain strip mines and inundate certain deep mine workings.

Winburne

a. Reconstruct stream channels in certain selected stream infiltration areas.
b. Restore a major subsidence area.
c. Restore certain selected strip mines.

SECTION IV --- MORRIS RUN STUDY AREA

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

MORRIS RUN STUDY AREA

General Description

The Morris Run Study Area is a wooded area covering approximately thirteen and one-half square miles of a portion of the Pennsylvania bituminous coal field in southeastern Tioga County. The Study Area is essentially defined by an isolated pocket of coal within the Pennsylvania bituminous field. In years prior to World War II, extensive deep mining was performed. There is currently no deep mining in the Study Area, nor is its resumption anticipated within the foreseeable future. Major strip mining commenced at the close of World War II. At present, extensive strip mining is being performed with an estimated 300,000 tons of coal per year being removed. Based on information currently available, strip mining will continue for the foreseeable future. MD has been discharged from the Study Area since the start of mining.

Streams within the Study Area receive MD from inactive deep and strip mines. These streams discharge into the Tioga River which flows northward into the Chemung River in New York State. The Chemung River then flows back into the Susquehanna River near Athens, Pennsylvania. No major public use is presently made of streams within the Study Area nor the Tioga River in Pennsylvania. The Corps of Engineers is currently preparing plans for construction in the near future of a flood control dam on the Tioga River in the vicinity of Tioga, Pennsylvania downstream from the Study Area. Although some coal exists and has been mined in sections of the Tioga River basin outside the Study Area, AMD pollution of the Tioga River is, for all practical purposes, caused solely by MD discharges within the Study Area.

With the exception of coal mining, farming, timber cutting, and a foundry operation located in the Borough of Blossburg, very little industry exists within or in close proximity to the Study Area. Much of the Study Area is open for public hunting. The Study Area and vicinity are sparsely populated with most inhabitants residing in Morris Run Village and the Borough of Blossburg.

The Morris Run Study Area is shown on Plate II (Morris Run).

Major Subsurface Conditions Causing AMD

Nine coal seams underlie the Morris Run Study Area, namely, the Brookville, Lower Kittanning, Foot, Middle Kittanning, Freak, Upper Kittanning, Monkey, Lower Freeport, and Upper Freeport seams. Acid producing materials are associated with all of these seams, most notably the Brookville, Lower Kittanning, and Lower Freeport. The major synclinal axis of the coal measures extends in a northeast-southwest direction roughly through the center of the Study Area. The bottom of this syncline is located toward the southwest portion of the Study Area. Coal seams rise gradually to the northwest and southeast from the synclinal axis to outcrop along the hillsides. Extensive deep mining was done in the Lower Kittanning, Upper Kittanning and Lower Freeport seams. Less extensive deep mining was done in the Brookville, Middle Kittanning, Upper Freeport, Foot, Freak, and Monkey seams. A typical configuration of coal seams in the Morris Run Study Area is shown on Plate III (Morris Run).

During the course of deep mining in the Morris Run Study Area, numerous entries were driven into the underground to gain access to the coal and to enable its removal. Since deep mining for the most part was conducted below then existing ground and perched water tables, various Drifts were driven to allow for the gravity discharge of MD from the workings. Gravity discharge could be ideally accomplished using Drifts because of the slope and location of coal seams in relation to the ground surface. These Drifts were at one of two general locations, namely at outcroppings along the southeast side of the middle and lower reaches of Morris Run as well as in low lying surface areas along the middle reaches of Bear and Coal Creeks. Deep mining was planned and conducted to allow for gravity discharge of MD from these Drifts. Only minimal steps were taken to provide for an effective barrier pillar system since such would have reduced the efficiency of the gravity MD plan initially developed and subsequently used by various operators over the years. In the Morris Run Study Area therefore, surface and ground waters finding their way into deep mine workings may flow for considerable distances over acid producing materials before eventually being discharged to surface streams as AMD

All coal seams in the Morris Run Study Area are in close proximity to the ground surface. The lowest seam subjected to extensive underground mining, namely the Lower Kittanning, is only 250 feet below ground surface at its maximum depth. The underground voids created by mining have caused extensive fissuring of the overburden throughout a significant portion of the Study Area. In some sections, the overburden has subsided into these underground voids. This fissuring and subsidence significantly reduces surface run-off and increases ground and surface water entry into inactive deep mine workings thereby increasing the severity of the AMD problem.

The extent of Morris Run deep mining, the location of deep mine entries, and other features of the Study Area are noted on Plate II (Morris Run).

Major Surface Conditions Causing AMD

Strip mining is currently being performed at a significant rate in the Middle and Upper Kittanning as well as in the Lower and Upper Freeport coal seams of the Morris Run Study Area. Limited strip mining has been performed in the Lower Kittanning, Foot, Freak and Monkey seams. It is estimated that one square mile of the Study Area is disturbed by inactive strip mines - six-tenths of a square mile by active strip mines. Inactive and active strip mines have disturbed approximately twelve per cent of the ground surface in the Study Area.

As a result of past inadequate restoration, strip mines in the Study Area serve as catch basins which collect, to varying degrees, direct precipitation, surface run-off, and ground water. Most of the waters so collected appear to find their way into deep mine workings through fissures in the bottom of the strip mines or through connections created where a strip mine cuts directly into deep mine workings. One of the inactive stripping operations located in the northeastern portion of the Study Area provides direct access to underground workings for all Morris Run flows. At this point, a portion of the flow carried by Morris Run results from precipitation outside the northern limit of the Study Area. Waters collected in strip mines have contact with acid producing materials located therein or connecting deep mines and are eventually discharged as AMD at one of the hereinbefore noted Drifts or other discharge points. In those cases where no direct connections exist between strip mine and inactive deep mine workings, water flows from the strip mine directly to surface streams creating another MD discharge point.

Refuse material from deep and strip mining on the surface of the Morris Run Study Area is another source of AMD. All of this Refuse, in varying degrees, is acid producing and the source of AMD discharges during periods of wet weather

The extent of Morris Run strip mining, both inactive and active, as well as the location of Refuse material in the Morris Run Study Area are indicated on Plate II (Morris Run).

Water Flow Routes Into, Through, and Out of Deep Mine Workings

A summary of the major points of connection between the ground surface and inactive deep mine workings in the Morris Run Study Area, as well as discharge points therefrom, is presented in the following:

1. Deep Mine Entries -

Seventy-two major deep mine entries exist in the Morris Run Study Area, nine of which are located in the Highwalls of strip mines. MD is discharged to surface streams from nine deep mine entries. The locations of all deep mine entries are noted on Plate II (Morris Run). There is presented on Exhibit A (Morris Run) a description of each deep mine entry noting where applicable those from which MD is discharged. Also presented on Exhibit A (Morris Run) are the MD discharge points with which the entries communicate.

2. Subsidence Areas -

Three major areas wherein the ground surface has subsided into underlying deep mine workings exist in the Morris Run Study Area. One of these subsidence areas crosses Bear Creek and provides ready access to deep mine workings for Bear Creek flows. The locations of subsidence areas are noted on Plate II (Morris Run). There is presented on Exhibit B (Morris Run) additional descriptive information relative to subsidence areas, and the MD discharge points with which the subsidence areas communicate.

3. Stream Infiltration Areas -

Four separate stretches of stream bed over which surface streams infiltrate in varying degrees to underlying deep mine workings are located in the Study Area. This condition was created by strip and deep mining in and beneath the respective stretches of stream bed. The location of stream infiltration areas are noted on Plate II (Morris Run). There is presented on Exhibit C (Morris Run) additional descriptive information pertaining to stream infiltration areas, and the MD discharge points with which they communicate.

4. Strip Mines -

Forty-one strip mines exist in the Study Area, thirty-nine of which are inactive. In all thirty-nine inactive strip mines, impounded waters reach deep mine workings by virtue of direct connections or infiltration. Intermittent MD discharges, caused by accumulations of precipitation, occur from five inactive strip mines. The locations of all strip mines are noted on Plate II (Morris Run). There is presented on Exhibit D (Morris Run) a description of each strip mine. Also noted on Exhibit D (Morris Run) are the MD discharge points with which strip mines communicate via deep mine workings, and the MD discharge points created by direct discharge from strip mines.

As noted hereinbefore, a major portion of the surface area underlaid with deep mines in the Morris Run Study Area has been extensively fissured. Therefore, in addition to the specific points of connection between the ground surface and deep mine workings located during the course of the investigations and studies reported herein surface and ground waters also have access to deep mine workings throughout the Study Area by way of the fissured overburden.

MD Gauging, Sampling and Analytical Program

With the exception of intermittent discharges from Study Area Refuse areas, sixteen MD discharges observed during investigations and studies reported herein were gauged, sampled and analyzed by FWPCA. Ten of these discharges occurred from deep mine workings, six of which appeared to be continuous in nature. Six occurred from inactive strip mines or other sources all of which appeared to be intermittent in nature. During the period covered by the FWPCA gauging, sampling and analytical program, combined Morris Run Study Area MD volumes, major constituents and characteristics approximated the following.

	Ground Water Level Periods		
	Low	Average	High
Volume - mgd	3.5	9	17
pH	3.0	3.0	3.0
Total iron - mg/l	115	80	60
Acid (as $CaCO_3$) - mg/l	790	640	500

Noted on Exhibit E (Morris Run) is a description of the sixteen MD discharge points covered by the FWPCA gauging, sampling and analytical program.

MD Design Volumes, Constituents and Characteristics

Combined MD design volumes, major constituents and characteristics used in developing individual Abatement Measures for the Morris Run Study Area are summarized in the following:

	Design Average	Design Wet Weather	Design Maximum
Volume - mgd	10.5	22.2	384
pH	3.0	3.0	3.0
Total iron - mg/l	80	60	30
- tons/day	3.5	5.6	46
Acid (as $CaCO_3$) - mg/l	690	510	320
- tons/day	30	47	510

Presented on Exhibit F (Morris Run) are the assumptions and calculations used for developing design Study Area MD volumes. On Exhibit G (Morris Run) there are presented the MD design volumes, constituents and characteristics for each discharge point covered by the FWPCA gauging, sampling and analytical program.

MD Discharges Not In Compliance With Current SWB Discharge Limitations

On the basis of design volumes, constituents and characteristics developed for the Morris Run Study Area, none of the Morris Run MD discharges meet current SWB discharge limitations. All sixteen MD discharges in the Morris Run Study Area have therefore been included in Abatement Plans developed for the Morris Run Study Area.

Applicable AMD Abatement Measures

For the Morris Run Study Area, seven Abatement Measures (six Preventive and one Treatment) were determined to be applicable in light of Study Area problems and conditions. Abatement Measures considered applicable for the Morris Run Study Area are set forth in the following:

- Preventive Measures
  - Reconstruct stream channels
  - Construct surface water diversion ditches
  - Restore strip mines
  - Move Refuse into strip mines
  - Excavate and restore subsidence areas
  - Construct impermeable seal on ground surface
- Treatment Measures
  - Chemically neutralize, oxidize, and settle in treatment facilities

The seven Abatement Measures described in the foregoing were used in developing Abatement Plans for the Morris Run Study Area. Because of subsurface and surface conditions, anticipated degree of accuracy in predicting effectiveness, SWB MD discharge limitations as well as relative treatment costs, other Abatement Measures reviewed as part of the investigations and studies reported herein were not considered applicable for the Morris Run Study Area.

AMD Abatement Plans Studied in Detail

In the Morris Run Study Area, four Abatement Plans consisting of various combinations of applicable Preventive and Treatment Measures were studied in detail. A brief description of these four Abatement Plans is presented in the following:

Abatement Plan I

Preventive Measures - None
Estimated AMD Reductions Attributable to Preventive Measures
Volume - None
Iron tonnage - None
Acid tonnage - None

Treatment Measures - All Study Area AMD

Abatement Plan II

Preventive Measures - Reconstruct stream channels in all stream infiltration areas; excavate and restore all subsidence areas; bury all Refuse material and restore selected strip mines; construct surface water diversion ditches around selected strip mines
Estimated AMD Reductions Attributable to Preventive Measures
Volume - 21%
Iron tonnage - 22%
Acid tonnage - 23%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan III

Preventive Measures - Reconstruct stream channels in all stream infiltration areas; excavate and restore all subsidence areas; bury all Refuse material and restore all strip mines

Abatement Plan III (Continued)

Estimated AMD Reductions Attributable to Preventive Measures
- Volume - 27%
- Iron tonnage - 26%
- Acid tonnage - 26%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan IV

Preventive Measures - Construct impermeable seal on the ground surface of that portion of the Study Area which contributes ground water to deep mine workings; reconstruct stream channels excavate and backfill subsidence area, move all Refuse material, and backfill all strip mines to accommodate construction of impermeable seal

Estimated AMD Reductions Attributable to Preventive Measures
- Volume - 100%
- Iron tonnage - 100%
- Acid tonnage - 100%

Treatment Measures - None

Collection Systems required in connection with Abatement Plans I, II and III include flow equalization basins and conveyance sewers. For cost estimating purposes, flow equalization basins were designed to store Design Maximum AMD Volumes from all tributary MD discharge points; conveyance sewers on the basis of Design Wet Weather Volumes. Treatment plants for Abatement Plans I, II and III were sized on the basis of Design Wet Weather Volumes.

Cost Estimates For AMD Abatement Plans Studied In Detail

A summary of costs associated with each Morris Run Study Area Abatement Plan studied in detail for purposes of this report is presented in the following:

		Total Annual Costs		
	Project Cost	Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Plan I	$ 4,498,000	$ 665,800	$512,100	$ 525,300
Plan II	6,769,000	741,200	423,520	455,285
Plan III	9,958,000	922,200	389,700	422,900
Plan IV	79,700,000	5,105,000	938,800	1,355,000

Discussion of AMD Abatement Plans Studied in Detail

A discussion of various factors important in evaluating Abatement Plans studied in detail for the Morris Run Study Area is presented in the following:

Abatement Plan I

While Project and initial thirty-year Total Annual Costs for Plan I would be less than for the other plans, Plan I with increased time would become more costly than Plans II and III. Since Plan I consists of treating all Study Area AMD at one location, collection and treatment facilities required to implement Plan I would have to be constructed in their entirety at one time before any reduction in AMD pollution would be realized from Plan I.

Abatement Plan II

Project and initial thirty-year Total Annual Costs for Plan II would be greater than for Plan I, but less than for Plans III and IV. With increased time, Total Annual Costs of Plan II would be less than for Plans I and IV, but more than for Plan III. Plan II Project Costs could be extended over several years by stage construction of the Preventive Measures comprising the plan. After constructing each Preventive

Measure, its impact on AMD reductions could be measured and subsequent Abatement Measures planned on the basis of this experience. Stage construction of Preventive Measures comprising Plan II would enable a given appropriation to be used in several areas affected by AMD thereby benefiting each area on a continuing basis. In addition to eliminating AMD pollution, some local aesthetic benefits would be realized from Plan II.

Abatement Plan III

Plan III possesses the same advantage as does Plan II insofar as stage construction of Preventive Measures is concerned. This plan would be more costly than Plan II initially but with increased time would become the least costly of all plans. More local aesthetic benefits would result from Plan III than Plan II.

Abatement Plan IV

Initial and Long Term Costs associated with Plan IV would be considerably greater than for the other plans. The only benefit to be realized from this greater cost would be the complete elimination of all AMD pollution regardless of the extent of precipitation. While construction of an impermeable seal appears to be the only Preventive Measure capable of completely eliminating AMD, it would for all practical purposes render useless for farming, timbering, etc., the area over which applied unless some auxiliary benefit from the seal could be obtained. Furthermore, it appears that a substantial portion of the impermeable seal would have to be constructed before any significant AMD reduction would be realized from Plan IV.

Recommended AMD Abatement Plan

On the basis of both Initial and Long Term Costs as well as the fact that it will enable the stage construction of applicable Preventive Measures, Abatement Plan II is recommended for construction in the Morris Run Study Area. The recommended order for constructing Preventive Measures comprising Abatement Plan II is set forth in the following:

Reconstruct stream channels in all stream infiltration areas.
Excavate and restore all major subsidence areas.
Construct surface water diversion ditches at strip mines
S-4, S-6, S-9, S-10, S-11, S-12, S-13, S-14, S-15, S-16, S-17, S-18, S-20, S-22, S-24, S-25, S-28, S-31, S-33, S-37, S-40 and S-41
Restore strip mines S-3, S-19, S-26, S-27, S-29, S-34, S-35 and S-36 (use Refuse to meet partial fill requirements)

Upon completing the construction of all Preventive Measures comprising Plan II, Treatment Measures to the extent required by then existing SWB MD discharge limitations could subsequently be provided. Project and unit cost information for the Preventive and Treatment Measures comprising recommended Abatement Plan II is summarized in the following:

		Total Annual Costs Per Ton Of Acid Removed		
	Project Cost	Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Preventive Measures	$3,750,000	$95.20	$ 4.80	$13.70
Treatment Measure	3,019,000	58.90	48.40	49.40

Noted on Plate IV (Morris Run) are the locations of the various Abatement Measures comprising recommended Abatement Plan II. For each MD discharge point covered by the FWPCA gauging, sampling and analytical program, there are presented on Exhibit H (Morris Run) estimates of AMD volumes, constituents and characteristics subsequent to construction of recommended Preventive Measures included in Abatement Plan II. For the various Preventive and Treatment Measures comprising Abatement Plan II, there is presented on Exhibit I (Morris Run), pertinent cost and other information.

EXHIBIT B (Morris Run)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Subsidence Areas

Subsidence Area (1)	Affected Area (Acres)	Coal Seam Into Which Overburden Has Subsided	MD Discharge Point With Which Subsided Area Communicates (1)
B-1	21	Lower Kittanning	1, 2, 5
B-2	9	Lower Kittanning	1, 2, 5
B-3	12	Lower Kittanning	5

(1) Refer to Plate II (Morris Run)

EXHIBIT C (Morris Run)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Stream Infiltration Areas

Infiltration Area (1)	Length (Feet)	Coal Seam Into Which Stream Flows Infiltrate	MD Discharge Point With Which Infiltration Area Communicates (1)
AA'	1,200	Lower Kittanning	1, 2
BB'	900	Lower Kittanning and Lower Freeport	1, 2
CC'	1,000	Lower Kittanning	5
DD'	1,200	Lower Kittanning	5

(1) Refer to Plate II (Morris Run)

EXHIBIT E (Morris Run)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of MD Discharge Points

Discharge Point (1)	Type Of Mine, And Coal Seam From Which MD Discharges	Type Of Discharge
1	Deep mine in Lower Kittanning seam	Artesian flow in bottom of stream bed through fractured rock strata; continuous, augmented by seasonal surface water infiltration
2	Deep mine in Lower Kittanning seam	Gravity flow through partially caved drift; intermittent, fluctuates with surface water infiltration
3	Strip mine in Lower Freeport seam	Overflow from pools in depressions in pit; intermittent, fluctuates with surface water infiltration
4	Deep mine in Brookville seam	Gravity flow through partially caved drift; intermittent, fluctuates with surface water infiltration
5	Deep mine in Lower Kittanning seam	Gravity flow through partially caved drift; continuous, augmented by seasonal surface water infiltration
6	Deep mine in Upper Kittanning seam	Gravity flow through partially caved drift; intermittent, fluctuates with surface water infiltration
7	Strip mine in Lower Freeport seam	Overflow from pools in depressions in pit; intermittent, fluctuates with surface water infiltration
8	Surface runoff and swamp overflow through acid forming material	Gravity flow through open channels; intermittent, fluctuates with surface water infiltration

EXHIBIT E (Morris Run Continued)
Page Two

Discharge Point (1)	Type Of Mine, And Coal Seam From Which MD Discharges	Type Of Discharge
9	Strip mine in Lower Freeport seam	Overflow from pools in depressions in pit; intermittent, fluctuates with surface water infiltration
10	Deep mine in Lower Kittanning seam	Gravity flow through open drift; continuous, augmented by seasonal surface water infiltration
11	Deep and strip mines in Lower Freeport seam	Overflow from pools in depressions in strip pit and deep mine workings; intermittent, fluctuates with surface water infiltration
12	Strip mine in Lower Freeport seam	Overflow from pools in depressions in pit; intermittent, fluctuates with surface water infiltration
13	Strip mine in Lower Freeport seam	Overflow from pools in depressions in pit; intermittent, fluctuates with surface water infiltration
14	Deep mine in Lower Kittanning seam	Gravity flow from partially caved drift; continuous, augmented by seasonal surface water infiltration
15	Deep mine in Lower Kittanning seam	Gravity flow from partially caved drift; continuous, augmented by seasonal surface water infiltration

EXHIBIT E (Morris Run Continued)
Page Three

Discharge Point (1)	Type Of Mine, And Coal Seam From Which MD Discharges	Type Of Discharge
16	Deep mine in Lower Kittanning seam	Gravity flow from partially caved drift; continuous, augmented by seasonal surface water infiltration

(1) Refer to Plate II (Morris Run)

EXHIBIT F (Morris Run)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Calculations And Assumptions For
Total Study Area Design MD Volumes

Design Average MD Volume

Estimated total average yearly precipitation in the Study Area and vicinity over the period of record (1) = 39 inches or 0.00445 in./hr

Study Area acreage = 8,215

Acreage outside of the Study Area contributing ground and surface waters to the Study Area = 440

Runoff coefficients
Study Area = 0.15
Area outside of the Study Area contributing ground and surface waters to the Study Area = 0.25

Base flow from area outside of the Study Area contributing ground and surface waters to the Study Area = 1.5 cfs/sq mi

Forty-five (45) per cent of the total precipitation on the Study Area assumed lost to the atmosphere by evaporation and transpiration

Precipitation on the Study Area infiltrating to underground workings -
Total available precipitation

$$39 \frac{\text{in.}}{\text{year}} \times 8{,}215 \text{ acres} \times 43{,}560 \frac{\text{sq ft}}{\text{acre}} \times \frac{1 \text{ ft}}{12 \text{ in.}} \times 7.48 \frac{\text{gal}}{\text{cu ft}} \times \frac{1 \text{ year}}{365 \text{ days}}$$

23.8 mgd

Losses

Surface water runoff directly to surface streams

$$0.15 \times 0.00445 \frac{\text{in.}}{\text{hr}} \times 8{,}215 \text{ acres} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$$

3.6 mgd

Evaporation and transpiration

$\frac{45}{100} \times 23.8$ mgd

10.7 mgd

Infiltration to underground workings

9.5 mgd

Precipitation outside of the Study Area contributing ground and surface waters to Study Area underground workings -

Base flow

$1.5 \frac{\text{cfs}}{\text{sq mi}} \times 440 \text{ acres} \times \frac{1 \text{ sq mi}}{640 \text{ acres}} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$

0.7 mgd

Surface runoff

$0.25 \times 0.00445 \frac{\text{in.}}{\text{hr}} \times 440 \text{ acres} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$

0.3 mgd

Total contribution to Study Area underground workings

1.0 mgd

Design average volume (total precipitation discharged from Study Area underground workings as MD)

10.5 mgd

Design Wet Weather MD Volume

Estimated total average precipitation in the Study Area and vicinity from December through April over the period of record (1)	13.2 inches

Conditions during gauging, sampling and analytical program (2) -	
AMD volume during high-ground water level period	16.8 mgd
Estimated total precipitation in the Study Area and vicinity (1)	9 inches
Precipitation deficiency	31.8 %
Design wet weather volume (total precipitation discharged from Study Area underground workings as MD)	22.2 mgd

Design Maximum MD Volume

Estimated total 24 hour accumulation of rainfall that will occur no more frequently than once every 10 years = 4.09 inches or 0.17 in./hr

Study Area acreage = 8,215

Acreage outside of the Study Area contributing ground and surface waters to the Study Area = 440

Runoff coefficients
Study Area = 0.15
Area outside of the Study Area contributing ground and surface waters to the Study Area = 0.35

Base flow from area outside of the Study Area contributing ground and surface waters to the Study Area = 1.5 cfs/sq mi

Forty-five (45) per cent of the total rainfall on the Study Area assumed lost to the atmosphere by evaporation and transpiration

Rainfall on the Study Area infiltrating to underground workings -
Total available rainfall

$$4.09\,\frac{\text{in.}}{\text{day}} \times 8{,}215 \text{ acres} \times 43{,}560\,\frac{\text{sq ft}}{\text{acre}} \times \frac{1\text{ ft}}{12\text{ in.}} \times 7.48\,\frac{\text{gal}}{\text{cu ft}}$$

912 mgd

EXHIBIT F (Morris Run Continued)
Page Four

Losses

Surface water runoff directly to surface streams

$$0.15 \times 0.17 \frac{\text{in.}}{\text{hr}} \times 8,215 \text{ acres} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$$

136 mgd

Evaporation and transpiration

$$\frac{45}{100} \times 912 \text{ mgd}$$

410 mgd

Infiltration to underground workings

366 mgd

Rainfall outside of the Study Area contributing ground and surface waters to Study Area underground workings -

Base flow

$$1.5 \frac{\text{cfs}}{\text{sq mi}} \times 440 \text{ acres} \times \frac{1 \text{ sq mi}}{640 \text{ acres}} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$$

0.7 mgd

Surface runoff

$$0.35 \times 0.17 \frac{\text{in.}}{\text{hr}} \times 440 \text{ acres} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$$

17 mgd

Total contributing to Study Area underground workings

17.7 mgd

Design maximum volume (total rainfall discharged from Study Area underground workings as MD)

384 mgd

(1) As equivalent inches of rainfall
(2) December 1966 through April 1967

SECTION V --- SHEPPTON STUDY AREA

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

SHEPPTON STUDY AREA

General Description

The Sheppton Study Area, located principally in northern Schuylkill County, covers approximately four and six-tenths square miles of a portion of the Pennsylvania anthracite coal fields. The Study Area is essentially defined by an isolated pocket of coal contained wholly within Green Mountain; it is commonly referred to as the South Green Mountain Basin. In years prior to World War II, extensive deep mining was performed in the Study Area. There is currently no deep mining nor is its resumption anticipated within the foreseeable future. Strip mining, although started as early as World War I, was not performed extensively in the Study Area until the advent of World War II. At present, limited strip mining is being performed with an estimated 50,000 tons of coal annually being removed. Based on information currently available, present strip mining operations in the Study Area are likely to be curtailed in the foreseeable future. MD has been discharged from the Study Area since the start of mining.

Catawissa Creek, laden with AMD and sewage from various upstream sources, enters the Sheppton Study Area from the east and immediately infiltrates Study Area inactive deep mine workings. Catawissa Creek subsequently discharges from the deep mine workings. Various Study Area MD discharges enter Catawissa Creek immediately after it discharges from Study Area deep mine workings as well as Tomhicken Creek which is tributary to Catawissa Creek. AMD is also discharged to Tomhicken Creek from mining operations located to the immediate north of the Study Area. Catawissa Creek flows in a general westerly direction from the vicinity of the Study Area to the Susquehanna River at Catawissa, Pennsylvania. No public use is presently made of Catawissa or Tomhicken Creek waters. An insignificant amount of MD from other portions of the anthracite fields downstream from the Study Area enters Catawissa Creek before its confluence with the Susquehanna River.

With the exception of coal mining, very little industry exists within or in close proximity to the Study Area. No public use is currently made of lands within the Study Area. The Study Area and vicinity are sparsely populated with most inhabitants residing in the villages of Oneida and Sheppton.

The Sheppton Study Area is shown on Plate II (Sheppton).

Major Subsurface Conditions Causing AMD

Nine coal veins are located in the Sheppton Study Area, namely, the Little Buck Mountain, Buck Mountain, Bottom Gamma, Top Gamma, Wharton, Bottom Split Mammoth, Middle Split Mammoth, Top Split Mammoth, and Primrose veins. Acid producing materials are associated with all of these veins. The Study Area synclinal axis extends in an east-west direction along the length of Green Mountain. Coal veins rise steeply to the north and south from the synclinal axis to outcrop close to the crest of Green Mountain. All coal veins in the Sheppton Study Area have been extensively deep mined. A typical configuration of the coal veins in the Sheppton Study Area is shown on Plate III (Sheppton).

In the development of deep mining within the Sheppton Study Area, Water Level Tunnels were driven from low lying surface areas to intercept the coal measures at their lowest possible elevation for drainage purposes. Other tunnels were driven through intervening rock strata to interconnect the coal veins at various elevations. This created an intricate MD system from which gravity MD flows still occur. A barrier pillar system existed between the mining operations of the two coal companies that removed coal from the Study Area. It is not known whether this system is totally effective at the present time. However, it is evident that surface and ground waters which find their way into Study Area deep mine workings may flow for considerable distances over acid producing materials before eventually being discharged to Study Area surface streams as AMD.

As coal was removed from coal veins in the Sheppton Study Area, mining approached the various coal surface croplines thereby weakening the strata supporting the ground surface. As a result, extensive fissuring and subsidence occurred along the outcrop of each coal vein mined near the surface. With the advent of strip mining, most of the croplines were stripped including those along which fissuring and subsidence had occurred. Therefore, in the Sheppton Study Area, fissuring and subsidence of the overburden now evident is confined principally to the unstripped central portion of the Study Area.

The exent of Sheppton Study Area deep mining, the location of deep mine entries and other geographic features of the Study Area are noted on Plate II (Sheppton).

Major Surface Conditions Causing AMD

All coal veins in the Sheppton Study Area, with the exception of the Little Buck Mountain vein, have been extensively stripped. Strip mining is currently performed in the central portion of the Study Area in accessible outcroppings. It is estimated that one and three-tenths square miles of the Study Area are disturbed by inactive strip mines; less than one-tenth of a square mile by active strip mines. Inactive and active strip mines have disturbed approximately twenty-eight per cent of the ground surface in the Study Area.

As a result of past inadequate restoration, strip mines in the Study Area serve as catch basins which collect to varying degrees, direct precipitation, surface runoff and ground water. Most of the waters so collected find their way into underlying deep mine workings exposed as the result of strip mine operations or through fissures in the bottom of the strip mines. One of the strip mines at the eastern end of the Study Area provides direct access to underground workings for all Catawissa Creek flows. Waters collected in Study Area strip mines have contact with acid producing materials in the strip and deep mines and are eventually discharged as AMD at one of the hereinbefore noted Water Level Tunnels. In one of the strip mines, a portion of the impounded waters overflows directly to Catawissa Creek after it discharges from deep mine workings, thus creating another MD discharge point.

Refuse resulting from past deep and strip mining operations exists throughout the Sheppton Study Area. Based on available information, it appears that MD discharged from this Refuse is not a significant source of AMD.

The extent of Sheppton Study Area strip mining, the location at which Catawissa Creek discharges into deep mine workings, and the locations of Refuse in the Study Area are noted on Plate II (Sheppton).

Water Flow Routes Into, Through, and Out Of Deep Mine Workings

The major points of connection between the ground surface and inactive deep mine workings in the Sheppton Study Area, as well as discharge points therefrom, are summarized in the following:

1. Deep Mine Entries -

   Twenty-nine deep mine entries exist in the Sheppton Study Area. Sixteen of the entries are located in previously stripped coal veins. Three of the deep mine entries (Water Level Tunnels) are MD discharge points. The location of these entries are noted on Plate II (Sheppton). There is presented on Exhibit A (Sheppton) a description of each deep mine entry, noting where applicable those from which MD is discharged. Also presented on Exhibit A (Sheppton) are the MD discharge points with which the entries communicate.

2. Subsidence Areas -

   There currently exist in the Sheppton Study Area five major areas wherein the ground surface has subsided into underlying deep mine workings. The location of these subsidence areas are noted on Plate II (Sheppton). There is presented on Exhibit B (Sheppton) additional descriptive information relative to subsidence areas and the MD discharge points with which they communicate.

3. Stream Infiltration Area -

One stream infiltration area exists in the Sheppton Study Area. This infiltration area is located where Catawissa Creek enters deep mine workings. Its location is indicated on Plate II (Sheppton). There is presented on Exhibit C (Sheppton) additional descriptive information pertaining to this infiltration area and the MD discharge points with which it communicates.

4. Strip Mines -

Five strip mines exist in the Sheppton Study Area; four of these are inactive. In all strip mines, impounded waters enter deep mine workings through direct connections or by means of infiltration. An intermittent MD discharge, caused by accumulations of precipitation, occurs from the active strip mine. The locations of all Sheppton Study Area strip mines are noted on Plate II (Sheppton). There is presented on Exhibit D (Sheppton) a description of each strip mine. Also noted on Exhibit D (Sheppton) are the MD discharge points with which the strip mines communicate via deep mine workings and the single MD discharge point created by direct discharge from the active strip mine.

As noted hereinbefore, available information indicates some fissuring of the overburden in central portions of the Sheppton Study Area. Therefore, in addition to the specific points of connection between the ground surface and deep mine workings located during the course of the investigations and studies reported herein, surface and ground waters also have access to deep mine workings through this fissured overburden.

MD Gauging, Sampling and Analytical Program

With the exception of those from Refuse areas, all MD discharges observed in the Sheppton Study Area during investigations and studies reported herein - four in number - were gauged, sampled and analyzed by

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FWPCA. Three of these discharges occurred from Water Level Tunnels and appeared continuous in nature; the fourth occurred from a strip mine and appeared intermittent in nature. For all practical purposes, MD discharged from one of the Water Level Tunnels consisted solely of Catawissa Creek flows. Catawissa Creek flows also contributed to MD discharges from a second Water Level Tunnel. During the period covered by the FWPCA gauging, sampling and analytical program, combined Sheppton Study Area MD volumes, major constituents and characteristics approximated the following:

	Ground Water Level Periods		
	Low	Average	High
Volume - mgd	6	12	20
pH	3.9	3.9	3.9
Total iron - mg/l	2	2	0.7
Acid (as $CaCO_3$) - mg/l	105	80	55

Noted on Exhibit E (Sheppton) is a description of the four MD discharge points covered by the FWPCA gauging, sampling and analytical program.

MD Design Volumes, Constituents And Characteristics

Combined MD design volumes, constituents and characteristics used in developing individual Abatement Measures for the Sheppton Study Area are summarized in the following:

	Design Average	Design Wet Weather	Design Maximum
Volume - mgd	13.6	21.2	432
pH	3.9	3.9	3.5
Total iron - mg/l	1.2	0.7	0.3
- tons/day	0.1	0.1	0.5
Acid (as $CaCO_3$) - mg/l	80	55	30
- tons/day	4.4	5.0	52.4

Presented on Exhibit F (Sheppton) are the assumptions and calculations used in developing design Study Area MD volumes. On Exhibit G (Sheppton) there are presented the MD design volumes, constituents and characteristics for each discharge point covered by the FWPCA gauging, sampling and analytical program.

MD Discharges Not In Compliance With Current SWB Discharge Limitations

On the basis of design volumes, constituents and characteristics developed for the Sheppton Study Area, none of the Sheppton MD discharges meet current SWB discharge limitations. All four MD discharges in the Sheppton Study Area have therefore been included in Abatement Plans developed for the Sheppton Study Area.

Applicable AMD Abatement Measures

For the Sheppton Study Area, seven Abatement Measures (six Preventive and one Treatment) were determined to be applicable in light of Study Area problems and conditions. Abatement Measures applicable for the Sheppton Study Area are set forth in the following:

Preventive Measures
- Inundate deep mine workings
- Reconstruct stream channels
- Construct surface water diversion ditches
- Restore strip mines
- Excavate and restore subsidence areas
- Construct impermeable seal on ground surface

Treatment Measure
- Chemically neutralize, oxidize, and settle in treatment facilities

The seven Abatement Measures described in the foregoing were used in developing Abatement Plans for the Sheppton Study Area. Because of subsurface and surface conditions, anticipated degree of accuracy in predicting effectiveness, SWB MD discharge limitations, as well as relative treatment costs, other Abatement Measures reviewed as part of investigations and studies reported herein were not considered applicable in the Sheppton Study Area.

AMD Abatement Plans Studied in Detail

In the Sheppton Study Area, six Abatement Plans including various combinations of applicable Preventive and Treatment Measures were studied in detail. A brief description of these six Abatement Plans is presented in the following:

Abatement Plan I

Preventive Measures	-	None
Estimated AMD Reductions Attributable to Preventive Measures		
Volume	-	None
Iron tonnage	-	None
Acid tonnage	-	None

Abatement Plan I (Continued)

Treatment Measures - All Study Area AMD including Catawissa Creek flows; no special provisions made for the sanitary sewage content of Catawissa Creek

Abatement Plan II

Preventive Measures - Reconstruct Catawissa Creek stream channel

Estimated AMD Reductions Attributable to Preventive Measures

- Volume - 45%
- Iron tonnage - 45%
- Acid tonnage - 43%

Treatment Measures - All AMD remaining after construction of Preventive Measure

Abatement Plan III

Preventive Measures - Reconstruct Catawissa Creek stream channel; construct surface water diversion ditches around and across selected strip mines

Estimated AMD Reductions Attributable to Preventive Measures

- Volume - 51%
- Iron tonnage - 51%
- Acid tonnage - 48%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan IV

Preventive Measures - Reconstruct Catawissa Creek stream channel; excavate and restore all subsidence areas; restore all strip mines; construct stream channels through and across restored strip mines; partially inundate deep mine workings

Abatement Plan IV (Continued)

Estimated AMD Reductions Attributable to Preventive Measures
Volume - 78%
Iron tonnage (1) - 25%
Acid tonnage (1) - 88%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan V

Preventive Measures - Reconstruct Catawissa Creek stream channel; partially inundate deep mine workings

Estimated AMD Reductions Attributable to Preventive Measures
Volume - 45%
Iron tonnage (1) - Increase
Acid tonnage (1) - 71%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan VI

Preventive Measures - Construct impermeable seal on the ground surface over that portion of the Study Area which contributes ground water to deep mine workings; Reconstruct Catawissa Creek stream channel, move all Refuse material, excavate and restore all subsidence areas, backfill all strip mines, and construct stream channels through and across all strip mines to accommodate construction of impermeable seal

Estimated AMD Reductions Attributable to Preventive Measures
Volume - 100%
Iron tonnage - 100%
Acid tonnage - 100%

Abatement Plan VI (Continued)

Treatment Measures - None

(1) Based on pool overflows at stabilized conditions

In Abatement Plans IV and V, MD discharges from the three Water Level Tunnels would be eliminated by virtue of constructing watertight seals within the tunnels. Based on information currently available, the mine water pools created as the result of sealing the Water Level Tunnels would rise and overflow at two new MD discharge points created at weak spots in the ground surface at significantly higher elevations than the Water Level Tunnels. One such discharge would probably be located in the southeastern portion of the Study Area and another in the northwestern portion of the Study Area.

Collection Systems required in connection with Abatement Plans I, II, III, IV, and V include flow equalization basins and conveyance sewers. For cost estimating purposes, flow equalization basins were designed to store Design Maximum AMD Volumes from all tributary MD discharge points; conveyance sewers on the basis of Design Wet Weather Volumes. Treatment plants for Abatement Plans I, II, III, IV, and V were sized on the basis of Design Wet Weather Volumes.

Cost Estimates for AMD Abatement Plans Studied In Detail

A summary of costs associated with each Sheppton Study Area Abatement Plan studied in detail for purposes of this report is presented in the following:

	Project Cost	Total Annual Costs		
		Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Plan I	$ 2,524,000	$ 420,900	$342,900	$350,600
Plan II	1,803,000	318,400	267,230	272,400
Plan III	1,701,000	309,700	262,450	267,200
Plan IV	8,996,000	676,550	115,900	172,000
Plan V	1,955,600	256,550	141,850	153,300
Plan VI	37,200,000	2,364,000	410,300	606,000

Discussion of AMD Abatement Plans Studied in Detail

A discussion of various factors important in evaluating Abatement Plans studied in detail for the Sheppton Study Area is presented in the following:

Abatement Plan I

Plan I Project Costs would be greater than the Project Costs for Plans II, III and V. On the basis of Long Term Costs, Plan I would be the second most expensive of all six plans studied in detail. Since Plan I consists of treating all Study Area AMD at two locations, one-half of all facilities required for Plan I would have to be constructed in one step before any reduction in AMD pollution would be realized from Plan I Abatement Measures.

Abatement Plan II

Preventive Measures comprising Plan II would convey Catawissa Creek through and out of the Study Area. Reductions in AMD pollution originating within the Study Area would be accomplished solely by treatment. As with Plan I, one-half of the Treatment Measures comprising Plan II would have to be constructed in a single step before any reductions in AMD pollution originating in the Study Area would be realized from Plan II Abatement Measures.

Abatement Plan III

Very little reduction in AMD pollution originating within the Study Area would be accomplished by Preventive Measures included in Plan III. For all practical purposes, one-half of the Treatment Measures included in Plan III would have to be constructed in a single step before any reduction in AMD pollution originating within the Study Area would be realized.

Abatement Plan IV

Although Long Term Costs for Plan IV would be less than for most other plans, its Project and initial thirty year Total Annual Costs would be considerably greater than for Plans I, II, III and V. Plan IV Project Costs could be spread over several years by constructing in stages the Preventive Measures included in the plan. After constructing each Preventive Measure, its impact on AMD reductions could be measured and Abatement Measures subsequently planned on the basis of said experience. Stage construction of Preventive Measures included in Plan IV would enable a given appropriation to be used in several areas affected by AMD, thereby benefiting each area on a continuing basis. Since deep mining for all practical purposes exhausted coal reserves not available by stripping in the Sheppton Study Area, no economic loss would result from inundation of the inactive workings in the Study Area. In addition to eliminating AMD pollution, some local aesthetic benefits would be realized from implementation of Plan IV.

Abatement Plan V

While Project Costs for Plan V would be slightly greater than for Plans II and III, Long Term Costs would be less than for all other plans. The only Preventive Measure included in Plan V that would result in a reduction of AMD pollution originating within the Study Area is inundation of deep mine workings. As with Plan IV, no economic loss would result from inundation of Study Area inactive deep mine workings under Plan V. The increase of iron concentrations attributable to Preventive Measures comprising Plan V would result from inundation of Study Area deep mine workings.

Abatement Plan VI

Project and Long Term Costs associated with Plan VI would be considerably greater than for the other plans. The only additional benefit to be realized from this increased cost would be the complete elimination of AMD pollution originating within the Study Area regardless of the extent of precipitation. While construction of an impermeable seal appears to be the only Preventive Measure currently capable of eliminating all AMD in the Sheppton Study Area, it would for all practical purposes render useless for farming, timbering, etc. the area over which applied unless some auxiliary benefit could be obtained. Furthermore, it appears that a substantial portion of the impermeable seal would have to be constructed before any significant AMD reduction could be realized.

Recommended AMD Abatement Plan

On the basis of both Initial and Long Term Costs, Abatement Plan V is recommended for construction in the Sheppton Study Area. The recommended order for constructing Preventive Measures included in Abatement Plan V is set forth in the following:

Reconstruct Catawissa Creek stream channel
Construct watertight seals in the three Water Level Tunnels

Upon completing the construction of all Preventive Measures comprising Abatement Plan V, the mine water pools created by sealing the Water Level Tunnels will have to be allowed to rise and overflow. Treatment Measures to the extent required by then existing SWB MD discharge limitations can subsequently be provided. Project and unit cost information for the Preventive and Treatment Measures comprising recommended Abatement Plan V is summarized in the following:

		Total Annual Costs Per Ton Of Acid Removed		
	Project Cost	Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Preventive Measures	$ 372,600	$20.40	$ 2.78	$ 4.55
Treatment Measure	1,583,000	492	292	312

On the basis of information currently available, it appears that the structural stability of the Water Level Tunnels and Study Area geology are such that seals can be effectively constructed in the Study Area to withstand the hydrostatic pressures resulting from inundation of the tunnels. More detailed studies should be made of the Water Level Tunnels and adjacent geological formations to verify this preliminary conclusion however before implementation of Plan V. Should detailed studies show that the effectiveness of seals in the Water Level Tunnels cannot be predicted with a high degree of certainty, it is recommended that Plan II or III subsequently be considered for implementation.

Noted on Plate IV (Sheppton) are the locations of the various Abatement Measures comprising recommended Abatement Plan V and the anticipated location of the new discharge points created by virtue of partially inundating Study Area deep mine workings. For each discharge point covered by the FWPCA gauging, sampling and analytical program, there are presented on Exhibit H (Sheppton) estimates of AMD volumes, constituents and characteristics subsequent to construction of recommended Preventive Measures comprising Abatement Plan V. Also presented on Exhibit H (Sheppton) are the AMD volumes, constituents and characteristics anticipated at the two new discharge points created by pool overflows. For the various Preventive and Treatment Measures comprising recommended Abatement Plan V, there is presented on Exhibit I (Sheppton), pertinent cost and other information.

EXHIBIT B (Sheppton)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Subsidence Areas

Subsidence Area (1)	Affected Area (Acres)	Coal Vein Into Which Overburden Has Subsided	MD Discharge Point With Which Subsidence Area Communicates (1)
B-1	8.7	Buck Mountain	1
B-2	2.8	Buck Mountain	1
B-3	6.8	Buck Mountain	2
B-4	2.3	Buck Mountain	2
B-5	1.5	Buck Mountain	1

(1) Refer to Plate II (Sheppton)

EXHIBIT C (Sheppton)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Stream Infiltration Area

Infiltration Area (1)	Length (Feet)	Coal Vein Into Which Stream Flows Infiltrate	MD Discharge Point With Which Infiltration Area Communicates (1)
AA'	3,000	Buck Mountain	2, 3

(1) Refer to Plate II (Sheppton)

EXHIBIT E (Sheppton)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of MD Discharge Points

Discharge Point (1)	Type Of Mine, and Coal Vein From Which MD Discharges	Type Of Discharge
1	Deep and strip mines in all veins	Gravity flow through rock tunnel (Coxe No. 3) driven from ground surface into deep mine; continuous, augmented by seasonal surface water infiltration
2	Deep and strip mines in all veins	Gravity flow through rock tunnel (Green Mountain) driven from ground surface into deep mine; continuous, augmented by seasonal surface water infiltration and Catawissa Creek diversion
3	Deep and strip mines in all veins	Gravity flow through rock tunnel (Green Mountain Water Level) driven from ground surface into deep mine; continuous, augmented by seasonal surface water infiltration and Catawissa Creek diversion
4	Strip mine in Buck Mountain vein	Overflow from pools in pit; intermittent, fluctuates with surface water infiltration

(1) Refer to Plate II (Sheppton)

EXHIBIT F (Sheppton)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Calculations And Assumptions For
Total Study Area Design MD Volumes

Design Average MD Volume

Estimated total average yearly precipitation in the Study Area and vicinity over the period of record (1) = 50 inches or 0.0057 in./hr

Study Area acreage = 2,958

Acreage outside of the Study Area contributing ground and surface waters to the Study Area = 3,977

Runoff coefficients
Study Area = 0.01
Area outside of the Study Area contributing ground and surface waters to the Study Area = 0.25

Base flow from area outside of the Study Area contributing ground and surface waters to the Study Area = 0.6 cfs/sq mi

Thirty (30) per cent of the total precipitation on the Study Area assumed lost to the atmosphere by evaporation and transpiration

Precipitation on the Study Area infiltrating to underground workings -
Total available precipitation

$$50\,\frac{\text{in.}}{\text{year}} \times 2{,}958 \text{ acres } 3\ 43{,}560\,\frac{\text{sq ft}}{\text{acre}} \times \frac{1\text{ ft}}{12\text{ in.}} \times 7.48\,\frac{\text{gal}}{\text{cu ft}} \times \frac{1}{365\text{ days}}\text{ year}$$

11 mgd

Losses

Surface water runoff directly to surface streams

$$0.01 \times 0.0057\,\frac{\text{in.}}{\text{hr}} \times 2{,}958 \text{ acres} \times 0.646\,\frac{\text{mgd}}{\text{cfs}}$$

0.1 mgd

EXHIBIT F (Sheppton Continued)
Page Two

Evaporation and transpiration

$\frac{30}{100} \times 11$ mgd

3.3 mgd

Infiltration to underground workings

7.6 mgd

Precipitation outside of the Study Area contributing ground and surface waters to Study Area underground workings -

Base flow

$0.6 \frac{\text{cfs}}{\text{sq mi}} \times 3{,}977 \text{ acres} \times \frac{1}{640 \text{ acres}} \text{ sq mi} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$

2.4 mgd

Surface runoff

$0.25 \times 0.0057 \frac{\text{in.}}{\text{hr}} \times 3{,}977 \text{ acres} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$

3.6 mgd

Total contribution to Study Area underground workings

6.0 mgd

Design average volume (total precipitation discharged from Study Area underground workings as MD)

13.6 mgd

Design Wet Weather MD Volume

Estimated total average precipitation in the Study Area and vicinity from December through April over the period of record (1)	17 inches

Conditions during gauging, sampling and analytical program (2) -

AMD volume during high ground water level period	20.2 mgd
Estimated total precipitation in the Study Area and vicinity (1)	16.3 inches
Precipitation deficiency	4.1 %

Design wet weather volume (total precipitation discharged from Study Area underground workings as MD)	21.1 mgd

Design Maximum MD Volume

Estimated total 24 hour accumulation of rainfall that will occur no more frequently than once every 10 years = 4.59 inches or 0.19 in./hr

Study Area acreage = 2,958

Acreage outside of the Study Area contributing ground and surface waters to the Study Area = 3,977

Runoff coefficients
Study Area = 0.01
Area outside of the Study Area contributing ground and surface waters to the Study Area = 0.35

Base flow from area outside of the Study Area contributing ground and surface waters to the Study Area = 1.5 cfs/sq mi

Thirty (30) per cent of the total rainfall on the Study Area assumed lost to the atmosphere by evaporation and transpiration

Rainfall on the Study Area infiltrating to underground workings -
Total available rainfall

$$4.59 \frac{\text{in.}}{\text{day}} \times 2{,}958 \text{ acres} \times 43{,}560 \frac{\text{sq ft}}{\text{acre}} \times \frac{1 \text{ ft}}{12 \text{ in.}} \times 7.48 \frac{\text{gal}}{\text{cu ft}}$$

368 mgd

Losses

Surface water runoff lost directly to surface streams

$$0.01 \times 0.19 \frac{\text{in.}}{\text{hr}} \times 2{,}958 \text{ acres} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$$

3.7 mgd

Evaporation and transpiration

$$\frac{30}{100} \times 368 \text{ mgd}$$

110 mgd

Infiltration to underground workings

254 mgd

Rainfall outside of the Study Area contributing ground and surface waters to Study Area underground workings -

Base flow

$$1.5 \frac{\text{cfs}}{\text{sq mi}} \times 3{,}977 \text{ acres} \times \frac{1 \text{ sq mi}}{640 \text{ acres}} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$$

6 mgd

Surface runoff

$$0.35 \times 0.19 \frac{\text{in.}}{\text{hr}} \times 3{,}977 \text{ acres} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$$

172 mgd

Total contributing to Study Area underground workings

178 mgd

Design maximum volume (total rainfall discharged from Study Area underground workings as MD)

432 mgd

(1) As equivalent inches of rainfall

(2) December 1966 through April 1967

SECTION VI --- TREMONT STUDY AREA

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

TREMONT STUDY AREA

General Description

The Tremont Study Area, located in western Schuylkill County, covers approximately six and seven-tenths square miles of a portion of the Pennsylvania anthracite coal fields. Coal veins underlying the Study Area extend for considerable distances beyond the limits of the Study Area. In years prior to World War II, extensive deep mining was performed in the Study Area. Extensive strip mining commenced during and shortly after World War II. At present, limited deep and strip mining is being performed in the Study Area with an estimated 110,000 tons of coal annually being removed. Based upon information currently available, present mining operations in the Study Area will probably be curtailed in the foreseeable future. MD has been discharged from the Study Area since the start of mining. The Pennsylvania Department of Mines and Mineral Industries is currently undertaking a program in the Study Area aimed at reducing the quantity of surface water entering deep mines through stream infiltration areas.

Streams in the Study Area receive MD from both active and inactive deep mine sources. MD discharged from active deep mines originates within inactive portions of the workings. All streams leaving the Study Area discharge into the headwaters of Swatara Creek which flows southwestward to the Susquehanna River near Harrisburg, Pennsylvania. No major public use is currently made of streams within the Study Area nor the headwaters of Swatara Creek. Mining areas to the west and east of the Study Area contribute significant AMD to the Swatara Creek watershed.

With the exception of limited coal mining and processing, very little industry exists within or in close proximity to the Study Area. No significant public use is currently made of lands within the Study Area. The Study Area and vicinity are sparsely populated with most inhabitants residing in the villages of Donaldson and Newtown. The Tremont Study Area is shown on Plate II (Tremont).

Major Subsurface Conditions Causing AMD

Thirty-one coal veins underlie the Tremont Study Area. These thirty-one veins are not continuous. No more than twenty-six are located at any one cross section. Acid producing materials are associated in varying degrees with all coal veins in the Tremont Study Area. All coal measures dip sharply to the south from outcroppings along the crest and southern slopes of Broad Mountain and plunge steeply several thousand feet beneath the ground surface. All coal veins in the Study Area have been deep mined from near their outcroppings to depths of several hundred feet. A typical configuration of major coal veins in the Tremont Study Area are shown on Plate III (Tremont).

When deep mines were developed in the Tremont Study Area, numerous entries were driven into the underground to gain access to the coal. These deep mine entries intercepted the then existing ground water table. Water Level Tunnels were driven from low lying surface areas to the coal

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measures to allow gravity discharge of MD from the workings. Other tunnels were driven through intervening rock strata to interconnect coal veins at various elevations thus creating an intricate gravity MD system. Available information indicates that the barrier pillar system existing within the Tremont Study Area was breached at various locations to facilitate gravity drainage. In the Tremont Study Area therefore, surface and ground waters finding their way into deep mine workings may flow for considerable distances over acid producing materials before eventually being discharged to surface streams as AMD. As deep mining progressed to deeper areas from which gravity drainage could not be obtained, the removal of mine waters was accomplished by a system of underground tunnels and pumps. When major deep mining was discontinued, three underground pools formed along the southern edge of the Study Area. These pools rose and overflowed to Good Spring Creek and Coal Run. Ground and surface waters finding their way into underground workings in the Study Area may therefore flow directly to a discharge point located at one of the Water Level Tunnels, or become impounded in one of the three mine water pools and overflow therefrom. At present, deep mining is conducted in the Tremont Study Area in coal veins lying above underground pool levels. Considerable coal reserves lie below existing mine water pools.

Underground voids created in the Study Area during the period of major deep mining caused extensive fissuring and subsidence of the ground surface along coal seam croplines. With the advent of strip mining, most of the croplines were stripped including those along which fissuring and subsidence had occurred. Therefore, current fissuring and subsidence of the ground surface is evident only in the unstripped northwest portion of the Study Area.

The extent of Study Area deep mining, the location of deep mine entries and other geographic features are noted on Plate II (Tremont).

Major Surface Conditions Causing AMD

In the Tremont Study Area, nearly all coal veins have been stripped at their outcroppings. Strip mining continues at the present time. It is estimated that one and six-tenths square miles of the Study Area are presently disturbed by inactive strip mines - less than one-tenth of a square mile by active strip mines. Inactive and active strip mines have disturbed approximately twenty-five per cent of the ground surface in the Study Area.

As a result of past inadequate restoration, strip mines in the Tremont Study Area serve as catch basins which collect, to varying degrees, direct precipitation, surface runoff and ground water. Since all strip mines are located on the southern slopes of Broad Mountain, they intercept virtually all surface runoff from higher elevations. Several inactive stripping operations located in a northeastern sector of the Study Area provide direct access to underground workings for all Gebhard Run flows. A portion of Gebhard Run flows in that sector of the Study Area result from precipitation beyond the northern limit of the Study Area. Waters collected in strip mines find their way into underlying deep mine workings exposed by the stripping operations, or through bottom fissures in the strip mines. These waters contact acid producing materials both in strip and deep mines and are eventually discharged as AMD at one of the hereinbefore noted MD discharge points.

Deposits of Refuse resulting from past mining operations exist throughout the Tremont Study Area. Based on available information, it appears that the MD discharged from this Refuse is not a significant source of AMD.

The extent of Tremont Study Area strip mining, both inactive and active, as well as the location of Refuse in the Tremont Study Area are indicated on Plate II (Tremont).

Water Flow Routes Into, Through and Out of Deep Mine Workings

A summary of the major points of connection between the ground surface and deep mine workings in the Tremont Study Area, as well as discharge points therefrom, is presented in the following:

1. Deep Mine Entries -

   Sixty-six deep mine entries exist in the Tremont Study Area. Twenty of these entries are located in strip mines. Four of the deep mine entries (Water Level Tunnels) serve as MD discharge points. The location of all deep mine entries are indicated on Plate II (Tremont). There is presented on Exhibit A (Tremont) a description of each deep mine entry, noting where applicable those from which MD is discharged. Also presented on Exhibit A (Tremont) are the MD discharge points with which the entries communicate.

2. Subsidence Areas -

   One major subsidence area exists within the Tremont Study Area. It is located near the headwaters of Coal Run. The location of this major subsidence area is noted on Plate II (Tremont). There is presented on Exhibit B (Tremont) additional descriptive information relative to this subsidence area and the MD discharge point with which it communicates.

3. Stream Infiltration Areas -

Eight separate stretches of stream bed into which surface streams infiltrate underlying deep mine workings are located in the Tremont Study Area. This condition was created by mining both in and beneath the stream beds. The location of stream infiltration areas in the Tremont Study Area are noted on Plate II (Tremont). There is presented on Exhibit C (Tremont) additional descriptive information pertaining to these stream infiltration areas and the MD discharge points with which they communicate.

4. Strip Mines -

Forty-one strip mines exist in the Tremont Study Area. Forty are inactive. In all inactive strip mines, impounded waters reach deep mine workings by means of direct connections or infiltration. The locations of all strip mines in the Tremont Study Area are noted on Plate II (Tremont). There is presented on Exhibit D (Tremont) a description of each strip mine. Also noted on Exhibit D (Tremont) are the MD discharge points with which the strip mines communicate via deep mine workings.

5. Mine Water Pool Overflows -

Four mine water pool overflows exist in the Tremont Study Area. One of these overflows, a Water Level Tunnel, provides relief for the mine water pool located in the southwesterly portion of the Study Area. Three mine water pool overflows created at weak spots in low lying surface areas tributary to Coal Run provide relief for the two mine water pools located in the south central and southeasterly portions of the Study Area. The location of all mine water pool overflows are noted on Plate II (Tremont). There is presented on Exhibit E (Tremont) a description of the mine water pool overflows as well as other MD discharge points.

MD Gauging, Sampling and Analytical Program

With the exception of intermittent discharges from Refuse areas, all MD discharges observed in the Tremont Study Area during investigations and studies reported herein - seven in number - were gauged, sampled and analyzed by FWPCA. Four of these MD discharges were observed to occur directly from mine water pools and three from the gravity drainage systems above mine water pool levels. Six of the MD discharges appeared continuous in nature. One appeared to be intermittent. During the period covered by the FWPCA gauging, sampling and analytical program, combined Tremont Study Area MD volumes, major constituents and characteristics approximated the following:

	Ground Water Level Periods		
	Low	Average	High
Volume - mgd	3.5	7	11
pH	3.5	3.5	3.5
Total iron - mg/l	45	35	30
Acid (as $CaCO_3$) - mg/l	180	150	130

Noted on Exhibit E (Tremont) is a description of the seven MD discharge points covered by the FWPCA gauging, sampling and analytical program.

MD Design Volumes, Constituents and Characteristics

Combined MD design volumes, major constituents and characteristics used in developing Abatement Measures for the Tremont Study Area are summarized in the following:

	Design Average	Design Wet Weather	Design Maximum
Volume - mgd	8.4	11.1	289
pH	3.5	3.5	3.5
Total iron - mg/l	35	30	20
- tons/day	1.2	1.3	21.5
Acid (as $CaCO_3$) - mg/l	150	130	105
- tons/day	5.2	6	126

Presented on Exhibit F (Tremont) are the assumptions and calculations used for developing design Study Area MD volumes. On Exhibit G (Tremont) there are presented the MD design volumes, constituents and characteristics for each MD discharge point covered by the FWPCA gauging, sampling and analytical program.

MD Discharges Not in Compliance With Current SWB Discharge Limitations

On the basis of MD design volumes, constituents and characteristics developed for the Tremont Study Area, none of the Tremont Study Area MD discharges meet current SWB discharge limitations. All seven MD discharges in the Tremont Study Area have therefore been included in the Abatement Plans developed for the Tremont Study Area.

Applicable AMD Abatement Measures

For the Tremont Study Area, seven Abatement Measures (six Preventive Measures and one Treatment Measure) were determined to be applicable in light of Study Area problems and conditions. Abatement Measures considered applicable for the Tremont Study Area are set forth in the following:

Preventive Measures
- Reconstruct stream channels
- Construct surface water diversion ditches
- Restore strip mines
- Excavate and restore subsidence areas
- Construct impermeable seal on ground surface
- Construct impermeable seal below ground surface

Treatment Measure
- Chemically neutralize, oxidize, and settle in treatment facilities

The seven Abatement Measures described in the foregoing were used in developing Abatement Plans for the Tremont Study Area. Because of subsurface and surface conditions, anticipated degree of accuracy in predicting effectiveness, SWB MD discharge limitations as well as relative treatment costs, other Abatement Measures reviewed as part of the investigations and studies reported herein were not considered applicable in the Tremont Study Area.

AMD Abatement Plans Studied in Detail

In the Tremont Study Area, five Abatement Plans consisting of various combinations of applicable Preventive and Treatment Measures were studied in detail. A brief description of these five Abatement Plans is presented in the following:

Abatement Plan I

Preventive Measures - None
Estimated AMD Reductions Attributable to Preventive Measures
  Volume - None
  Iron tonnage - None
  Acid tonnage - None

Treatment Measures - All Study Area AMD

Abatement Plan II

Preventive Measures - Divert Gebhard Run from deep mine entry D-22; reconstruct stream channels in all stream infiltration areas; construct surface water diversion ditches around selected strip mines; construct impermeable seal below ground surface in the area of the settling basins located in the south central portion of the Study Area

Abatement Plan II (Continued)

Estimated AMD Reductions Attributable to Preventive Measures
Volume - 20%
Iron tonnage - 15%
Acid tonnage - 22%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan III

Preventive Measures - Divert Gebhard Run from deep mine entry D-22; reconstruct stream channels in all stream infiltration areas; restore all strip mines; construct impermeable seal below ground surface in the area of the settling basins located in the south central portion of the Study Area

Estimated AMD Reductions Attributable to Preventive Measures
Volume - 34%
Iron tonnage - 34%
Acid tonnage - 37%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan IV

Preventive Measures - Divert Gebhard Run from deep mine entry D-22; reconstruct stream channels in all stream infiltration areas; construct surface water diversion ditches around selected strip mines

Estimated AMD Reductions Attributable to Preventive Measures
Volume - 18%
Iron tonnage - 18%
Acid tonnage - 22%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan V

Preventive Measures - Construct impermeable seal on the ground surface of that portion of the Study Area which could contribute ground water to deep mine workings; reconstruct stream channels in all stream infiltration areas, divert Gebhard Run from deep mine entry D-22, move all Refuse material, and backfill all strip mines to accommodate construction of impermeable seal

Estimated AMD Reductions Attributable to Preventive Measures
Volume - 100%
Iron tonnage - 100%
Acid tonnage - 100%

Treatment Measures - None

As part of Abatement Plans I, II, III and IV, certain AMD discharges would be diverted to strip mines communicating with MD discharge points located nearer proposed treatment facilities. Collection Systems required in connection with these Abatement Plans include, among other things, flow equalization basins, conveyance sewers, boreholes and borehole pumps. For cost estimating purposes, flow equalization basins were designed to store Design Maximum AMD Volumes from one or more gravity MD discharge points; conveyance sewers, boreholes and pumps on the basis of Design Wet Weather Volumes. All gravity AMD discharges would be conveyed to flow equalization basins; pumped AMD discharges would be conveyed directly to proposed treatment facilities. The three pool overflows located in low lying surface areas tributary to Coal Run would be eliminated by means of pumping from the two pools in the south central and southeasterly portions of the Study Area. Treatment plants for Abatement Plans I, II, III and IV were sized on the basis of Design Wet Weather Volumes.

Cost Estimates for AMD Abatement Plans Studied in Detail

A summary of costs associated with each Tremont Study Area Abatement Plan studied in detail for purposes of this report is presented in the following:

		Total Annual Costs		
	Project Cost	Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Plan I	$ 1,616,300	$ 306,680	$270,400	$274,000
Plan II	2,698,000	342,100	243,500	253,400
Plan III	12,810,000	966,100	215,300	290,400
Plan IV	2,299,800	302,750	228,900	225,665
Plan V	58,200,000	3,700,000	635,500	942,000

Discussion of AMD Abatement Plans Studied in Detail

A discussion of various factors important in evaluating Abatement Plans studied in detail for the Tremont Study Area is presented in the following:

Abatement Plan I

The Project Costs for Plan I would be less than for all other Plans. Initial thirty-year Total Annual Costs for Plans I and IV would for all practical purposes be equal and less than for other plans. Plan I with increased time would be more costly than Plans II, III and IV. Since Plan I contemplates treating all Tremont Study Area AMD at one location, all Treatment Measures included in Plan I would have to be constructed in one step before any reductions in AMD pollution would be realized from Plan I.

Abatement Plan II

Project and Total Annual Costs for Plan II would be greater than for Plan IV. Plan II Project Costs could be extended over several years by stage construction of the Preventive Measures comprising the plan. After constructing each Preventive Measure, its impact on AMD reduction could subsequently be measured and subsequent Abatement Measures planned on the basis of this experience. Stage construction of Preventive Measures would also enable a given appropriation to be used in several areas affected by AMD, thereby benefiting each area on a continuing basis.

Abatement Plan III

Plan III Project and initial thirty-year Total Annual Costs would be considerably higher than for Plans I, II and IV. With increased time, Total Annual Costs for Plans III and IV would become for all practical purposes equal and less than for the other plans. Although Plan III possesses the same advantage as does Plan II insofar as the stage construction of Preventive Measures is concerned, it does so at considerably greater Initial Costs. More local aesthetic benefits would result from Plan III than from Plans II and IV.

Abatement Plan IV

Plan IV possesses the same advantages as does Plan II insofar as the stage construction of Preventive Measures is concerned. Reductions of AMD pollution resulting from Preventive Measures comprising Plan IV would for all practical purposes equal those of Plan II. Project and Total Annual Costs for Plan IV would be less than comparable costs for Plan II.

Abatement Plan V

Project and Long Term Costs for Plan V would be considerably greater than costs for other plans. The only benefit to be realized from this greater cost would be the complete elimination of AMD pollution regardless of the extent of precipitation. While construction of an impermeable seal appears to be the only Preventive Measure currently capable of eliminating AMD, it would for all practical purposes render useless for farming, timbering, etc. the area over which applied unless some auxiliary benefit from the seal could be obtained. Furthermore, it appears that a substantial portion of the impermeable seal would have to be constructed before any significant AMD reduction would be realized.

Recommended AMD Abatement Plan

On the basis of both Initial and Long Term Costs as well as the fact that it will enable the construction of applicable Preventive Measures in stages, Abatement Plan IV is recommended for construction in the Trem[illegible] Study Area. The recommended order for constructing Preventive Measures included in Abatement Plan IV is set forth in the following:

> Divert Gebhard Run from deep mine entry D-22 and reconstruct stream channel in stream infiltration area BB'.
> Reconstruct stream channels in all other stream infiltration areas.
> Construct surface water diversion ditches at strip mines S-1, S-5, S-5a, S-6, S-9, S-23, S-26, S-27, S-29, S-30, S-31 and S-37.

Upon completing construction of all Preventive Measures comprising Plan IV, Treatment Measures to the extent required by then existing SWB MD discharge limitations can subsequently be provided. Project and unit cost information for the Preventive and Treatment Measures comprising recommended Abatement Plan IV is summarized in the following:

		Total Annual Costs Per Ton Of Acid Removed		
	Project Cost	Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Preventive Measures	$ 528,600	$97.50	$39.30	$45.10
Treatment Measure	1,771,200	180	146	149

Noted on Plate IV (Tremont) are the locations of the various Abatement Measures comprising recommended Abatement Plan IV. For each MD discharge point covered during the FWPCA gauging, sampling and analytical program, there are presented on Exhibit H (Tremont) estimates of AMD volumes, constituents and characteristics subsequent to construction of recommended Preventive Measures comprising a portion of Abatement Plan IV. For the various Preventive and Treatment Measure comprising Abatement Plan IV, there is presented on Exhibit I (Tremont) pertinent cost and other information.

EXHIBIT B (Tremont)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Subsidence Area

Subsidence Area (1)	Affected Area (Acres)	Coal Vein Into Which Overburden Has Subsided	MD Discharge Point With Which Subsidence Area Communicates (1)
B-1	2.7	Buck Mountain	2

(1) Refer to Plate II (Tremont)

EXHIBIT C (Tremont)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Stream Infiltration Areas

Infiltration Area (1)	Length (Feet)	Coal Vein Into Which Stream Flows Infiltrate	MD Discharge Point With Which Infiltration Area Communicates (1)
AA'	2,900	Seven Foot Bottom Split Mammoth Middle Split Mammoth Top Split Mammoth Primrose	2
BB'	2,000	No. 3	3, 4
CC'	2,900	Buck Mountain through Orchard	2
DD'	200	No. 3	4
EE'	2,000	Buck Mountain through Tracy	2, 5
FF'	1,000	Lykens Valley Nos. 4 & 5 Buck Mountain through Orchard	2, 5
GG'	1,200	Buck Mountain through Seven Foot	2, 5
HH'	1,500	Buck Mountain through Tracy	5

(1) Refer to Plate II (Tremont)

EXHIBIT E (Tremont)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of MD Discharge Points

Discharge Point (1)	Type Of Mine, And Coal Vein From Which MD Discharges	Type Of Discharge
1	Deep and strip mines in Buck Mountain vein	Gravity flow through rock tunnel driven from ground surface into deep mine; continuous, augmented by seasonal surface water infiltration
2	Deep and strip mines in Tracy through Buck Mountain veins	Gravity overflow from underground mine water pool through strip mine interconnected with deep mine; continuous, augmented by seasonal surface water infiltration
3	Deep and strip mines in Nos. 1 through 6 veins	Gravity overflow from underground mine water pool through strip mine interconnected with deep mine; intermittent, fluctuates with surface water infiltration
4	Deep and strip mines in Nos. 1 through 6 veins	Artesian flows from underground mine water pool in bottom of stream bed through fractured rock strata; continuous, augmented by seasonal surface water infiltration

EXHIBIT E (Tremont Continued)
Page Two

Discharge Point (1)	Type Of Mine, And Coal Vein From Which MD Discharges	Type Of Discharge
5	Deep and strip mines in Orchard through Seven Foot veins	Gravity flow from underground mine water pool through rock tunnel driven from ground surface into deep mine; continuous, augmented by seasonal surface water infiltration
6	Deep and strip mines in Lykens Valley Nos. 1, 2 and 3 veins	Gravity flow through rock tunnel driven from ground surface into deep mine; continuous, augmented by seasonal surface water infiltration
7	Deep and strip mines in Lykens Valley Nos. 2, 3, 4 and 5 veins	Gravity flow through rock tunnel driven from ground surface into deep mine; continuous, augmented by seasonal surface water infiltration

(1) Refer to Plate II (Tremont)

EXHIBIT F (Tremont)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Calculations And Assumptions For Total Study Area Design MD Volumes

Design Average MD Volume

Estimated total average yearly precipitation in the Study Area and vicinity over the period of record (1) = 49 inches or 0.00547 in./hr

Study Area acreage = 4,300

Runoff coefficient
Study Area = 0.063

Forty (40) per cent of the total precipitation on the Study Area assumed lost to the atmosphere by evaporation and transpiration

In the northwestern portion of the Study Area, precipitation lost by runoff to the north compensates for precipitation discharged into the Study Area by Gebhard Run

Precipitation on the Study Area infiltrating to underground workings -

Total available precipitation

$$49 \frac{\text{in.}}{\text{year}} \times 4{,}300 \text{ acres} \times 43{,}560 \frac{\text{sq ft}}{\text{acre}} \times \frac{1 \text{ ft}}{12 \text{ in.}} \times 7.48 \frac{\text{gal}}{\text{cu ft}} \times \frac{1 \text{ year}}{365 \text{ days}}$$

15.7 mgd

Losses

Surface water runoff directly to surface streams

$$0.063 \times 0.00547 \frac{\text{in.}}{\text{hr}} \times 4{,}300 \text{ acres} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$$

1.0 mgd

EXHIBIT F (Tremont Continued)
Page Two

Evaporation and transpiration

$$\frac{40}{100} \times 15.7 \text{ mgd}$$

6.3 mgd

Infiltration to underground workings
8.4 mgd

Design average volume (total precipitation discharged from Study Area underground workings as MD)
8.4 mgd

Design Wet Weather MD Volume

Estimated total average precipitation in the Study Area and vicinity from December through April over the period of record (1)	17 inches
Conditions during gauging, sampling and analytical program (2) -	
AMD volume during high ground water level period	10.6 mgd
Estimated total precipitation in the Study Area and vicinity (1)	16.3 inches
Precipitation deficiency	4.1 %
Design wet weather volume (total precipitation discharged from Study Area underground workings as MD)	11.1 mgd

Design Maximum MD Volume

Estimated total 24 hour accumulation of rainfall that will occur no more frequently than once every 10 years = 4.61 inches or 0.19 in./hr

EXHIBIT F (Tremont Continued)
Page Three

Study Area acreage = 4,300

Runoff coefficient
Study Area = 0.063

Forty (40) per cent of the total rainfall on the Study Area assumed lost to the atmosphere by evaporation and transpiration

In the northwestern portion of the Study Area, rainfall lost by runoff to the north compensates for rainfall discharged into the Study Area by Gebhard Run

Rainfall on the Study Area infiltrating to underground workings -

Total available rainfall

$$4.61\,\frac{\text{in.}}{\text{day}} \times 4{,}300 \text{ acres} \times 43{,}560\,\frac{\text{sq ft}}{\text{acre}} \times \frac{1 \text{ ft}}{12 \text{ in.}} \times 7.48\,\frac{\text{gal}}{\text{cu ft}}$$

539 mgd

Losses

Surface water runoff lost directly to surface streams

$$0.063 \times 0.19\,\frac{\text{in.}}{\text{hr}} \times 4{,}300 \text{ acres} \times 0.646\,\frac{\text{mgd}}{\text{cfs}}$$

34 mgd

Evaporation and transpiration

$$\frac{40}{100} \times 539 \text{ mgd}$$

216 mgd

Infiltration to underground workings
289 mgd

Design maximum volume (total rainfall discharged from Study Area underground workings as MD)
289 mgd

(1) As equivalent inches of rainfall
(2) December 1966 through April 1967

SECTION VII --- COALDALE STUDY AREA

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

COALDALE STUDY AREA

General Description

The Coaldale Study Area, covering approximately twelve and three-tenths square miles of a portion of the Pennsylvania bituminous coal fields, is located in northeastern Bedford County. Coal seams underlying the Study Area extend for considerable distances beyond its boundaries. In years prior to World War II, the Study Area was extensively deep mined. Some strip mining began with the advent of World War II. At present, both deep and strip mining operations are limited. Approximately 20,000 tons of coal are mined annually. Based upon information currently available, present mining operations in the Study Area will probably be curtailed in the foreseeable future. MD has been discharged from the Study Area since the start of mining operations. Field investigations and other available information indicate that the Works Progress Administration of the Federal Government constructed a number of air seals in various Study Area deep mine entries during the 1930's. During field investigations reported herein, AMD was being discharged from those entries where the air seals were still intact.

The Coaldale Study Area is drained by Sixmile Run. All MD originating within the Study Area is discharged to Sixmile Run and its tributaries. Sixmile Run flows into the Raystown Branch of the Juniata River. The Juniata River flows in an easterly direction from its confluence with the Raystown Branch to the Susquehanna River near Harrisburg, Pennsylvania. No major public use is presently made of Sixmile Run or its tributaries. The Raystown

Branch of the Juniata downstream from Sixmile Run supports public fishing. All AMD pollution of Sixmile Run is caused by MD discharges originating within the Study Area. Mined areas both upstream and downstream from the Study Area also contribute AMD to the Juniata.

In addition to mining, farming and timber cutting constitute other work activities conducted in the Study Area. Much of the Study Area is open for the public hunting of both small and large game. The Study Area and immediate vicinity are sparsely populated. Most inhabitants reside in the villages of Finleyville, North Point, Coaldale and Defiance. The Coaldale Study Area is shown on Plate II (Coaldale).

Major Subsurface Conditions Causing AMD

Six coal seams underlie the Coaldale Study Area, namely the Clarion, Lower Kittanning, Middle Kittanning, Upper Freeport, Speer and Pittsburgh seams. Acid producing materials are associated with all of these seams. The coal measures underlying the Study Area are severely folded and faulted. The major synclinal axis of the seams dips gradually from the northernmost portion of the Study Area toward the village of Defiance subsequently rising toward the southwest until it leaves the Study Area. Coal measures in the Study Area rise steeply from the major synclinal axis. Severe geologic upheavals resulted in a series of minor synclines and anticlines that parallel the major syncline. Generally the anticlines are found near the crests of ridges with synclines underlying the valleys and ravines. Extensive Study Area deep mining has been conducted in the Clarion, Lower Kittanning and Upper Freeport seams - limited deep mining in the Middle Kittanning, Speer and Pittsburgh seams. A typical configuration of coal seams in the Study Area is shown on Plate III (Coaldale).

In developing deep mines located within the Coaldale Study Area, numerous entries were driven into the ground to gain access to the coal. Since deep mining for the most part was conducted below the then existing ground water table, various Drifts were driven to allow for the gravity discharge of MD from the workings in a part of the Study Area. Gravity MD discharge could be accomplished through Drifts in many cases because of the slope and location of coal seams in relation to the ground surface. As a result of coal seam folding and faulting, tunnels were driven through intervening rock strata to interconnect various coal seams for drainage purposes. Only minimal steps were taken to provide for an effective barrier pillar system. In the Coaldale Study Area therefore, surface and ground waters which find their way into deep mine workings may flow for considerable distances over acid producing materials before being discharged to surface streams as AMD. In portions of the Study Area from which gravity drainage was not possible, the removal of mine waters had to be accomplished by a system of underground tunnels and pumps. When deep mining was discontinued, various underground pools, approximately six in number, were formed mainly in the central and southeasterly portions of the Study Area. The pools subsequently overflowed to Sixmile Run and its tributaries. Ground and surface waters reaching underground workings in the Study Area may flow directly to a discharge point located at one of the deep mine entries or become impounded in one of the mine water pools and overflow therefrom.

At present, deep mining is conducted only in those portions of the Study Area where coal seams lie above MD pool levels.

In certain sections of the Coaldale Study Area, coal seams lie in close proximity to the ground surface. Whereas in certain other study areas covered by this report, the mining of coal from seams near the surface resulted in extensive subsidence and fissuring of the ground surface, the geology of the Coaldale Study Area kept surface subsidence and fissuring to a minimum.

The extent of Coaldale Study Area deep mining, the location of deep mine entries and other geographic features of the Study Area are noted on Plate II (Coaldale).

Major Surface Conditions Causing AMD

In the Coaldale Study Area, strip mining continues at present in the Pittsburgh seam. Strip mining in the past was performed mainly in the Lower and Middle Kittanning, Upper Freeport and Speer seams. It is estimated that one-half square mile of the Study Area is disturbed at present as the result of inactive strip mines - less than one-tenth of a square mile by active strip mines. Inactive and active strip mines together have disturbed approximately five per cent of the Study Area.

As a result of past inadequate restoration, strip mines in the Study Area serve as catch basins which collect, to varying degrees, direct precipitation, surface runoff, and ground water. Waters so collected appear to find their way into deep mine workings through fissures in the bottom of strip mines and/or through deep mine workings exposed by strip mine operations. These waters contact acid producing material in both the strip and deep mines and eventually are discharged as AMD at one of the numerous MD discharge points located within the Study Area.

Deposits of Refuse resulting from past mining operations exist throughout the Coaldale Study Area. Based on available information, it appears that MD discharged from this Refuse is not a source of AMD.

The extent of Coaldale Study Area strip mine operations, both inactive and active, as well as the location of Refuse in the Study Area are shown on Plate II (Coaldale).

Water Flow Routes Into, Through, and Out Of Deep Mine Workings

A summary of the major points of connection between the ground surface and deep mine workings in the Coaldale Study Area, as well as discharge points therefrom, is presented in the following:

1. Deep Mine Entries -

   One hundred seventeen deep mine entries currently exist in the Coaldale Study Area. Six of these entries are located in the Highwalls of strip mines. Twenty of the deep mine entries serve as MD discharge points. The locations of all deep mine entries are noted on Plate II (Coaldale). There is presented on Exhibit A (Coaldale) a description of each deep mine entry, noting where applicable those from which MD is discharged. Also presented on Exhibit A (Coaldale) are the MD discharge points with which the entries communicate.

2. Subsidence Areas -

Two major areas wherein the ground surface has subsided into underlying deep mine workings exist in the Coaldale Study Area. Their locations are noted on Plate II (Coaldale). There is presented on Exhibit B (Coaldale) additional descriptive information relative to subsidence areas, and the MD discharge points with which the subsidence areas communicate.

3. Stream Infiltration Areas -

Three separate stretches of stream bed into which surface streams infiltrate underlying deep mine workings are located in the Coaldale Study Area. This condition was created by mining beneath the stream beds. Stream infiltration areas are shown on Plate II (Coaldale). There is presented on Exhibit C (Coaldale) additional descriptive information pertaining to these stream infiltration areas, and the MD discharge points with which they communicate.

4. Strip Mines -

Twenty-eight strip mines currently exist in the Coaldale Study Area. Twenty-six are presently inactive. In all twenty-six inactive strip mines, impounded waters reach deep mine workings by means of direct connections or infiltration. The locations of all strip mines are noted on Plate II (Coaldale). There is presented on Exhibit D (Coaldale) a description of each strip mine. Also noted on Exhibit D (Coaldale) are the MD discharge points with which the strip mines communicate via deep mine workings.

5. Mine Water Pool Overflows -

It appears that seven mine water pool overflows exist in the Coaldale Study Area. Four of these overflows are from deep mine entries. Three are due to weak spots in low lying surface areas tributary to Sixmile Run. The locations of mine water pool overflows are shown on Plate II (Coaldale). There is presented on Exhibit E (Coaldale) a description of the pool overflows and other MD discharge points.

MD Gauging, Sampling and Analytical Program

With the exception of intermittent discharges from Refuse areas, all MD discharges observed in the Coaldale Study Area during investigations and studies reported herein - twenty-four in number - were gauged, sampled and analyzed by FWPCA. Seven of these discharges appeared to occur from mine water pools, the remainder from the gravity drainage system above pool levels. Nineteen of the MD discharges appeared continuous in nature. Five appeared intermittent in nature. During the period covered by the FWPCA gauging, sampling and analytical program, combined Coaldale Study Area MD volumes, major constituents and characteristics approximated the following:

	Ground Water Level Periods		
	Low	Average	High
Volume - mgd	1.5	2.9	4.7
pH	3.0	3.0	3.0
Total iron - mg/l	35	25	15
Acid (as $CaCO_3$) - mg/l	320	270	215

Noted on Exhibit E (Coaldale) is a description of the twenty-four MD discharge points covered by the FWPCA gauging, sampling and analytical program.

MD Design Volumes, Constituents and Characteristics

Combined MD design volumes, major constituents and characteristics used in developing individual Abatement Measures for the Coaldale Study Area are summarized by condition of discharge in the following:

	Design Average	Design Wet Weather	Design Maximum
Volume - mgd	3.5	5.4	78
pH	3.0	3.0	3.0
Total iron - mg/l	25	15	10
- tons/day	0.4	0.4	3.3
Acid (as $CaCO_3$) - mg/l	270	215	125
- tons/day	4	4.8	40.9

Presented on Exhibit F (Coaldale) are the assumptions and calculations used for developing design Study Area MD volumes. On Exhibit G (Coaldale) there are presented the MD design volumes, constituents and characteristics for each MD discharge point covered by the FWPCA gauging, sampling and analytical program.

MD Discharges Not In Compliance With Current SWB Discharge Limitations

On the basis of MD design volumes, constituents and characteristics developed for the Coaldale Study Area, none of the Coaldale MD discharges meet current SWB discharge limitations. All twenty-four discharges in the Coaldale Study Area have therefore been included in the Abatement Plans developed for the Coaldale Study Area.

Applicable AMD Abatement Measures

For the Coaldale Study Area, five Abatement Measures (four Preventive Measures and one Treatment Measure) were determined to be applicable in light of Study Area problems and conditions. Abatement Measures considered applicable for the Coaldale Study Area are set forth in the following:

Preventive Measures
- Reconstruct stream channels
- Restore strip mines
- Inundate deep mine workings
- Construct impermeable seal on ground surface

Treatment Measure
- Chemically neutralize, oxidize, and settle in treatment facilities

The five Abatement Measures described in the foregoing were used in developing Abatement Plans for the Coaldale Study Area. Because of subsurface and surface conditions, anticipated degree of accuracy in predicting effectiveness SWB MD discharge limitations as well as relative treatment costs, other Abatement Measures reviewed as part of investigations and studies reported herein were not considered applicable for the Coaldale Study Area.

AMD Abatement Plans Studied In Detail

In the Coaldale Study Area, three Abatement Plans consisting of various combinations of applicable Preventive and Treatment Measures were studied in detail. A brief description of these three Abatement Plans is presented in the following.

Abatement Plan I

Preventive Measures - None
Estimated AMD Reductions Attributable to Preventive Measures
Volume - None
Iron tonnage - None
Acid tonnage - None

Treatment Measures - All Study Area AMD

Abatement Plan II

Preventive Measures - Reconstruct stream channels in all stream infiltration areas; restore selected strip mines; inundate selected deep mine workings

Estimated AMD Reductions Attributable to Preventive Measures
Volume - 21%
Iron tonnage - 22%
Acid tonnage - 18%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan III

Preventive Measures - Construct impermeable seal on the ground surface of that portion of the Study Area which contributes ground water to deep mine workings; reconstruct stream channels in all stream infiltration areas, move all Refuse material, and backfill all strip mines to accommodate construction of impermeable seal

Estimated AMD Reductions Attributable to Preventive Measures
Volume - 100%
Iron tonnage - 100%
Acid tonnage - 100%

Treatment Measures - None

Under Abatement Plan II, two MD discharge points would be eliminated by constructing certain watertight seals. Based on information currently available, the mine water pools created as a result of these seals would probably rise and completely inundate the rather limited workings behind the seals. AMD pollution should be significantly reduced as a result. Pools thus created would become part of the general ground water table in the area.

Collection Systems required in connection with Abatement Plans I and II include, among other things, flow equalization basins, conveyance sewers, boreholes and borehole pumps. For cost estimating purposes, flow equalization basins were designed to store Design Maximum AMD Volumes from one or more gravity MD discharge points; conveyance sewers, boreholes and pumps on the basis of Design Wet Weather Volumes. All gravity AMD discharges would be conveyed to flow equalization basins; pumped AMD discharges would be conveyed directly to conveyance sewers. Treatment plants for Abatement Plans I and II were sized on the basis of Design Wet Weather Volumes.

Cost Estimates For AMD Abatement Plans Studied In Detail

A summary of costs associated with each Coaldale Abatement Plan studied in detail for purposes of this report is presented in the following:

		Total Annual Costs		
	Project Cost	Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Plan I	$ 2,509,000	$ 322,800	$ 247,400	$ 254,900
Plan II	2,586,500	290,700	204,400	213,000
Plan III	92,900,000	5,970,000	1,154,000	1,630,000

Discussion of AMD Abatement Plans Studied In Detail

A discussion of various factors important in evaluating Abatement Plans studied in detail for the Coaldale Study Area is presented in the following:

Abatement Plan I

While estimated Project Costs for Plan I would be slightly less than for Plan II, Total Annual Costs would be greater.

Since Plan I contemplates treating all Study Area AMD at one location, Treatment Measures included in Plan I would have to be constructed in one step before any reductions in AMD pollution would result from Plan I.

Abatement Plan II

Plan II Project Costs could be extended over several years by stage construction of the Preventive Measures included in the plan. After constructing each Preventive Measure, its impact on AMD reductions could then be measured and subsequent Abatement Measures planned on the basis of said experience. Stage construction of Preventive Measures comprising Plan II would enable a given appropriation to be used in several areas affected by AMD thereby benefiting each area on a continuing basis. Although there appears to be coal reserves in deep mine workings that would be inundated as part of this plan, said reserves are limited in nature. In addition to eliminating AMD pollution, some limited local aesthetic benefits would be realized from Plan II.

Abatement Plan III

Project as well as Total Annual Costs for Plan III would be considerably greater than similar costs for other plans. The only benefit to be realized from this greater cost would be the complete elimination of AMD pollution from Sixmile Run regardless of the extent of precipitation in the Study Area. While construction of an impermeable seal currently appears to be the only Preventive Measure capable of eliminating AMD in the Study Area, it would for all practical purposes render useless for farming, timbering, etc. the land over which applied unless some auxiliary benefit could be obtained therefrom. Furthermore, it appears that a substantial portion of the impermeable seal would have to be constructed before any significant AMD reductions would be realized from the plan.

Recommended AMD Abatement Plan

On the basis of both Initial and Long Term Costs as well as the fact that it will enable construction of applicable Preventive Measures in stages, Abatement Plan II is recommended for construction in the

Coaldale Study Area. The recommended order for constructing Preventive Measures included in Abatement Plan II is set forth in the following:

Reconstruct stream channels in all stream infiltration areas, and in the vicinity of AMD discharges 17 and 23 (DD' and EE').
Restore strip mine S-20 and construct watertight seal in deep mine entry D-100 (Refuse used to meet partial fill requirement)
Construct watertight seal in deep mine entry D-110
Restore strip mine S-15 (Refuse used to meet partial fill requirement)

Upon completing the construction of all Preventive Measures comprising Plan II, Treatment Measures to the extent required by then existing SWB MD discharge limitations can subsequently be provided. Project and unit cost information for the Preventive and Treatment Measures comprising recommended Abatement Plan II are summarized in the following:

		Total Annual Costs Per Ton Of Acid Removed		
	Project Cost	Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Preventive Measures	$ 411,500	$104	$12.90	$22.00
Treatment Measure	2,175,000	226	172	178

Noted on Plate IV (Coaldale) are the locations of the various Abatement Measures comprising recommended Abatement Plan II. For each MD discharge point covered by the FWPCA gauging, sampling and analytical program, there are presented on Exhibit H (Coaldale) estimates of AMD volumes, constituents and characteristics subsequent to construction of recommended Preventive Measures comprising Abatement Plan II. For the various Preventive and Treatment Measures comprising Abatement Plan II, there is presented on Exhibit I (Coaldale) pertinent cost and other information.

EXHIBIT B (Coaldale)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Subsidence Areas

Subsidence Area (1)	Affected Area (Acres)	Coal Seam Into Which Overburden Has Subsided	MD Discharge Point With Which Subsided Area Communicates (1)
B-1	1.7	Middle Kittanning	17, 22
B-2	13.6	Clarion and Lower Kittanning	14

(1) Refer to Plate II (Coaldale)

EXHIBIT C (Coaldale)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Stream Infiltration Areas

Infiltration Area (1)	Length (Feet)	Coal Seam Into Which Stream Flows Infiltrate	MD Discharge Point With Which Infiltration Area Communicates (1)
AA'	1,500	Upper Freeport	19
BB'	3,500	Upper Freeport	15, 16
CC'	500	Upper Freeport	14

(1) Refer to Plate II (Coaldale)

EXHIBIT E (Coaldale)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of MD Discharge Points

Discharge Point (1)	Type Of Mine, And Coal Seam From Which MD Discharges	Type Of Discharge
1	Deep mine in Upper Freeport seam	Gravity flow through intact mine seal; continuous, augmented by seasonal surface water infiltration
2	Deep mine in Clarion seam	Gravity flow through partially caved, formerly sealed drift, continuous, augmented by seasonal surface water infiltration
3	Deep mine in Clarion seam	Gravity flow through three caved drifts; continuous, augmented by seasonal surface water infiltration
4	Deep mine in Clarion seam	Overflow from mine water pool around filled shaft; intermittent, fluctuates with surface water infiltration
5	Deep mine in Clarion seam	Gravity flow through caved drift; intermittent, fluctuates with surface water infiltration
6	Deep mine in Lower Kittanning seam	Gravity flow through intact mine seal; intermittent, fluctuates with surface water infiltration
7	Deep mine in Lower Kittanning seam	Gravity flow through caved drift; intermittent, fluctuates with surface water infiltration

EXHIBIT E (Coaldale Continued)
Page Two

Discharge Point (1)	Type Of Mine, And Coal Seam From Which MD Discharges	Type Of Discharge
8	Deep mine in Lower Kittanning seam	Gravity flow through caved drift; continuous, augmented by seasonal surface water infiltration
9	Deep mine in Lower Kittanning seam	Gravity flow through caved slope; continuous, augmented by seasonal surface water infiltration
10	Deep mine in Upper Freeport seam	Gravity flow through caved drift; continuous, augmented by seasonal surface water infiltration
11	Deep mine in Upper Freeport seam	Gravity flow through caved drift; continuous, augmented by seasonal surface water infiltration
12	Deep mine in Clarion seam	Gravity flow through intact mine seal; continuous, augmented by seasonal surface water infiltration
13	Deep mine in Upper Freeport seam	Gravity flow through partially caved drift; continuous, augmented by seasonal surface water infiltration
14	Deep mine in Clarion seam	Gravity flow through caved drift; continuous, augmented by seasonal surface water infiltration
15	Deep mine in Upper Freeport seam	Gravity flow from mine water pool through intact mine seal; continuous, augmented by seasonal surface water infiltration

EXHIBIT E (Coaldale Continued)
Page Three

Discharge Point (1)	Type Of Mine, And Coal Seam From Which MD Discharges	Type Of Discharge
16	Deep mine in Upper Freeport seam	Gravity flow from mine water pool through partially caved drainage tunnel; continuous, augmented by seasonal surface water infiltration
17	Deep mine in Upper Freeport seam	Gravity flow from mine water pool through ground surface adjacent to mine seal marker; continuous, augmented by seasonal surface water infiltration
18	Deep mine in Speer seam	Gravity flow through intact mine seal; continuous, augmented by seasonal surface water infiltration
19	Deep mine in Upper Freeport seam	Gravity flow from mine water pool through partially caved drift; continuous, augmented by seasonal surface water infiltration
20	Deep mine in Upper Freeport seam	Gravity flow through ground surface from deep mine workings; continuous, augmented by seasonal surface water infiltration
21	Deep mine in Clarion seam	Gravity flow through open drift; continuous, augmented by seasonal surface water infiltration
22	Deep mine in Middle Kittanning seam	Gravity flow through partially caved drift; intermittent, fluctuates with surface water infiltration

EXHIBIT E (Coaldale Continued)
Page Four

Discharge Point (1)	Type Of Mine, And Coal Seam From Which MD Discharges	Type Of Discharge
23	Deep mine in Clarion seam	Artesian flow from mine water pool in bottom of stream bed through fractured rock strata; continuous, augmented by seasonal surface water infiltration
24	Deep mines in Clarion and Lower Kittanning seams	Artesian flow from mine water pool through previously capped borehole; continuous, augmented by seasonal surface water infiltration

(1) Refer to Plate II (Coaldale)

EXHIBIT F (Coaldale)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Calculations And Assumptions For Total Study Area Design MD Volumes

Design Average MD Volume

Estimated total average yearly precipitation in the Study Area and vicinity over the period of record (1) = 40 inches or 0.00457 inches/hour

Study Area acreage = 7,857

Runoff coefficient
Study Area = 0.37

Forty-eight (48) per cent of the total precipitation on the Study Area assumed lost to the atmosphere by evaporation and transpiration

Precipitation on the Study Area infiltrating to underground workings -

Total available precipitation

$$40\ \frac{\text{in.}}{\text{year}} \times 7{,}857\ \text{acres} \times 43{,}560\ \frac{\text{sq ft}}{\text{acre}} \times \frac{1\ \text{ft}}{12\ \text{in.}} \times 7.48\ \frac{\text{gal}}{\text{cu ft}} \times \frac{1\ \text{year}}{365\ \text{days}}$$

23.3 mgd

Losses

Surface water runoff directly to surface streams

$$0.37 \times 0.00457\ \frac{\text{in.}}{\text{hr}} \times 7{,}857\ \text{acres} \times 0.646\ \frac{\text{mgd}}{\text{cfs}}$$

8.6 mgd

Evaporation and transpiration

$$\frac{48}{100} \times 23.3\ \text{mgd}$$

11.2 mgd

Infiltration to underground workings
3.5 mgd

EXHIBIT F (Coaldale Continued)
Page Two

Design average volume (total precipitation discharged from Study Area underground workings as MD)
3.5 mgd

Design Wet Weather MD Volume

Estimated total average precipitation in the Study Area and vicinity from December through April over the period of record (1) 15.8 inches

Conditions during gauging, sampling and analytical program (2) -
AMD volume during high ground water level period 4.7 mgd
Estimated total precipitation in the Study Area and vicinity (1) 13.6 inches
Precipitation deficiency 13.9 %

Design wet weather volume (total precipitation discharged from Study Area underground workings as MD) 5.4 mgd

Design Maximum MD Volume

Estimated total 24 hour accumulation of rainfall that will occur no more frequently than once every 10 years = 4.39 inches or 0.18 in./hr

Study Area acreage = 7,857

Runoff coefficient
Study Area = 0.44

Forty-eight (48) per cent of the total rainfall on the Study Area assumed lost to the atmosphere by evaporation and transpiration

Rainfall on the Study Area infiltrating to underground workings -
Total available rainfall

$$4.39 \frac{\text{in.}}{\text{day}} \times 7{,}857 \text{ acres} \times 43{,}560 \frac{\text{sq ft}}{\text{acre}} \times \frac{1 \text{ ft}}{12 \text{ in.}} \times 7.48 \frac{\text{gal}}{\text{cu ft}}$$

936 mgd

Losses

Surface water runoff directly to surface streams

$$0.44 \times 0.18 \frac{\text{in.}}{\text{hr}} \times 7,857 \text{ acres} \times 0.646 \frac{\text{mgd}}{\text{cfs}}$$

409 mgd

Evaporation and transpiration

$$\frac{48}{100} \times 936 \text{ mgd}$$

449 mgd

Infiltration to underground workings

78 mgd

Design maximum volume (total rainfall discharged from Study Area underground workings as MD)

78 mgd

(1) As equivalent inches of rainfall
(2) December 1966 through April 1967

SECTION VIII --- WINBURNE STUDY AREA

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

WINBURNE STUDY AREA

General Description

The Winburne Study Area covers approximately six and one-tenth square miles of a portion of the Pennsylvania bituminous coal fields in eastern Clearfield County. Coal seams underlying the Study Area extend for considerable distances beyond its boundaries. In years prior to World War II, the Study Area was extensively deep mined. Strip mining began after World War II. At present, both strip and deep mining are performed with an estimated 200,000 tons of coal annually removed. Based on available information, present mining operations in the Study Area will probably be curtailed in the foreseeable future. MD has been discharged from the Study Area since the start of mining. Field investigations and other available information indicate that the Works Progress Administration of the Federal Government constructed a number of air seals in various Study Area deep mine entries during the 1930's. During field investigations reported herein AMD was being discharged from all of those entries where the air seals were still intact.

MD originating in the Winburne Study Area is discharged from inactive deep mines directly to Sulfur Run and its tributaries. Sulphur Run, for all practical purposes, begins in the Study Area. Sulfur Run flows into Moshannon Creek. Moshannon Creek subsequently flows into the West Branch of the Susquehanna River near Karthaus, Pennsylvania. No major public use is currently made of streams within the Study Area or Moshannon

Creek. Moshannon Creek receives MD discharges throughout most of its entire length.

Other than coal mining and related activities, farming is the only industry existing within or in close proximity to the Study Area. Public use of lands within the Study Area is limited to small and large game hunting. The Study Area and vicinity are sparsely populated. Most inhabitants reside in the villages of Winburne and Lanse. The Winburne Study Area is shown on Plate II (Winburne).

Major Subsurface Conditions Causing AMD

Four coal seams underlie the Winburne Study Area, namely the Brookville, Lower Kittanning, Middle Kittanning and Upper Kittanning seams. Acid producing materials are associated with all of these seams. One of the major synclines associated with bituminous coal fields located in central Pennsylvania (Houtzdale Syncline) passes through the Study Area. The Houtzdale Syncline enters the Study Area from the northeast and pitches downward to a location immediately west of the village of Winburne. From this point the syncline rises to a local roll and fault and thereafter leaves the Study Area at its southwestern limits. Coal measures rise gradually from the synclinal axis to the extremities of the Study Area. Deep mining in the past was limited to the Lower Kittanning seam. Currently, deep mining is being performed in the Brookville seam. A typical configuration of coal seams in the Winburne Study Area is shown on Plate III (Winburne).

In developing deep mines located within the Winburne Study Area, numerous entries were driven into the ground to gain access to the coal. Since deep mining for the most part was conducted below the then existing ground water table, Drifts were driven to allow for the gravity discharge of MD from the workings. Gravity discharge could be ideally accomplished because of the slope and location of the coal seams in relation to the ground surface. These Drifts were generally located at outcroppings along the northeast side of Sulphur Run as well as in low lying surface areas adjacent to the lower reaches of Sulphur Run tributaries. Deep mine development was conducted to allow for gravity discharge of MD from the Drifts. Only minimal steps were taken to provide for an effective barrier pillar system since such a system would have reduced the efficacy of the gravity MD plan. In the Winburne Study Area therefore, surface and ground waters finding their way into deep mine workings may flow for considerable distances over acid forming material before eventually being discharged to surface streams as AMD.

All coal seams in the Winburne Study Area are located in close proximity to the ground surface. The lowest seam subjected to extensive mining, namely the Lower Kittanning, is only 170 feet below ground surface as its maximum depth. Underground voids created by deep mining caused extensive fissuring of the overburden throughout a significant portion of the Study Area. In some sections of the Study Area, the overburden has subsided into these underground voids. Fissuring and subsidence in the Study Area significantly reduces surface runoff, increases ground and surface water entering the deep mine workings and, consequently, the severity of the AMD problem.

Precipitation falling on that portion of the Study Area lying within the Browns Run watershed infiltrates the shallow, fissured strata overlying the Lower Kittanning deep mine workings and contributes to MD discharge points on Sulphur Run through interconnected deep mine workings.

The extent of deep mine operations, the location of deep mine entries, and other geographic features of the Study Area are shown on Plate II (Winburne).

Major Surface Conditions Causing AMD

In the Winburne Study Area, the Middle Kittanning coal seam has been extensively stripped. The Lower Kittanning has also been stripped but less extensively than the Middle Kittanning seam. Both the Middle and Upper Kittanning seams are currently being stripped. It is estimated that one square mile of the Study Area is presently disturbed by inactive strip mines and approximately two-tenths of a square mile by active strip mines. Inactive and active strip mine operations together have disturbed approximately twenty per cent of the Study Area.

As a result of past restoration inadequacies, strip mines in the Study Area serve as catch basins that collect, in varying degrees, direct precipitation, surface runoff, and ground water. Waters so collected appear to find their way into deep mine workings through fissures in the bottom of the strip mines and/or through deep mine workings exposed by stripping operations. These waters, after contacting acid producing materials in both the strip and deep mines, are eventually discharged as AMD to surface streams in the Study Area.

Deposits of Refuse resulting from past mining operations exist throughout the Winburne Study Area. Some of this Refuse is acid producing and the source of AMD discharges during periods of wet weather.

The extent of Winburne Study Area strip mine operations, both inactive and active, as well as the location of Refuse in the Study Area are shown on Plate II (Winburne).

Water Flow Routes Into, Through, and Out Of Deep Mine Workings

A summary of the major points of connection between the ground surface and deep mine workings in the Winburne Study Area, as well as discharge points therefrom, is presented in the following:

1. Deep Mine Entries -

   Twenty-one major deep mine entries exist in the Study Area. MD is discharged to surface streams through eight of these deep mine entries. The locations of all deep mine entries are noted on Plate II (Winburne). There is presented on Exhibit A (Winburne) a description of each deep mine entry, noting where applicable those from which MD is discharged. Also presented on Exhibit A (Winburne) are the MD discharge points with which the entries communicate.

2. Subsidence Area -

   One major area wherein the ground surface has subsided into underlying deep mine workings lies within the Winburne Study Area. The location of this subsidence area is noted on Plate II (Winburne). There is presented on Exhibit B (Winburne) additional descriptive information relative to the subsidence area and the MD discharge points with which it communicates.

3. Stream Infiltration Areas -

Five separate stretches of stream bed through which surface streams infiltrate underlying deep mine workings are located in the Winburne Study Area. This condition was created by mining in and beneath the stream beds. The locations of stream infiltration areas are noted on Plate II (Winburne). There is presented on Exhibit C (Winburne) additional descriptive information pertaining to these stream infiltration areas and the MD discharge points with which they communicate.

4. Strip Mines -

Twenty-one strip mines currently exist in the Winburne Study Area. Eighteen of these are inactive. In all eighteen inactive strip mines, impounded waters reach deep mine workings by means of direct connections or infiltration. The locations of all strip mines are noted on Plate II (Winburne). There is presented on Exhibit D (Winburne) a description of each strip mine. Also noted on Exhibit D (Winburne) are the MD discharge points with which the strip mines communicate via deep mine workings.

As noted hereinbefore, information currently available indicates that a major portion of the ground surface in the Winburne Study Area underlaid with deep mine workings has been extensively fissured. Consequently, in addition to the specific points of connection between the ground surface and deep mine workings located during the course of the investigations and studies reported herein, surface and ground waters also have access to deep mine workings in the Study Area through the fissured overburden.

MD Gauging, Sampling And Analytical Program

With the exception of intermittent discharges from Refuse areas, all MD discharges observed in the Winburne Study Area during investigations and Studies reported herein - thirteen in number - were gauged, sampled and analyzed by FWPCA. All of these discharges were observed to occur from deep mine workings. Twelve appeared continuous in nature. One appeared intermittent. During the period covered by the FWPCA gauging, sampling and analytical program, combined Winburne Study Area MD volumes, major constituents and characteristics approximated the following:

	Ground Water Level Periods		
	Low	Average	High
Volume - mgd	1.1	6	13
pH	2.9	2.9	2.9
Total iron - mg/l	290	205	160
Acid (as $CaCO_3$) - mg/l	1,160	940	815

Noted on Exhibit E (Winburne) is a description of the thirteen MD discharge points covered by the FWPCA gauging, sampling and analytical program.

MD Design Volumes, Constituents and Characteristics

Combined MD design volumes, major constituents and characteristics used in developing Abatement Measures for the Winburne Study Area are summarized by condition of discharge in the following:

	Design Average	Design Wet Weather	Design Maximum
Volume - mgd	6.2	14.9	204
pH	2.9	2.9	2.9
Total iron - mg/l	205	160	95
- tons/day	5.3	9.9	80
Acid (as $CaCO_3$) - mg/l	940	815	615
- tons/day	24.4	50.8	618

Presented on Exhibit F (Winburne) are the assumptions and calculations used for developing design Study Area MD volumes. On Exhibit G (Winburne) there are presented the MD design volumes, constituents and characteristics for each MD discharge point covered by the FWPCA gauging, sampling and analytical program.

MD Discharges Not In Compliance With Current SWB Discharge Limitations

On the basis of MD design volumes, constituents and characteristics developed for the Winburne Study Area, none of the Winburne MD discharges meet current SWB discharge limitations. All thirteen MD discharges in the Winburne Study Area have therefore been included in the Abatement Plans developed for the Winburne Study Area.

Applicable AMD Abatement Measures

For the Winburne Study Area, eight Abatement Measures (seven Preventive Measures and one Treatment Measure) were determined to be applicable in light of Study Area problems and conditions. Abatement Measures considered applicable for the Winburne Study Area are set forth in the following:

Preventive Measures
- Reconstruct stream channels
- Construct surface water diversion ditches
- Restore strip mines
- Move Refuse into strip mines
- Restore subsidence areas
- Construct impermeable seal on ground surface
- Construct impermeable seal below ground surface

Treatment Measure
- Chemically neutralize, oxidize, and settle in treatment facilities

The eight Abatement Measures described in the foregoing were used in developing Abatement Plans for the Winburne Study Area. Because of subsurface and surface conditions, anticipated degree of accuracy in predicting effectiveness, SWB MD discharge limitations as well as relative treatment costs, other Abatement Measures reviewed as part of investigations and studies reported herein were not considered applicable in the Winburne Study Area.

AMD Abatement Plans Studied in Detail

In the Winburne Study Area, five Abatement Plans consisting of various combinations of applicable Preventive and Treatment Measures were studied in detail. A brief description of these five Abatement Plans is presented in the following:

Abatement Plan I

Preventive Measures - None
Estimated AMD Reductions Attributable to Preventive Measures
Volume - None
Iron tonnage - None
Acid tonnage - None

Treatment Measures - All Study Area AMD

Abatement Plan II

Preventive Measures - Reconstruct stream channels in all stream infiltration areas; restore major subsidence area; restore selected strip mines
Estimated AMD Reductions Attributable to Preventive Measures
Volume - 10%
Iron tonnage - 11%
Acid tonnage - 11%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan III

Preventive Measures - Reconstruct stream channels in all stream infiltration areas; restore major subsidence area; restore selected strip mines in addition to those covered by Plan II

Estimated AMD Reductions Attributable to Preventive Measures

Volume - 15%
Iron tonnage - 23%
Acid tonnage - 19%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan IV

Preventive Measures - Reconstruct stream channels in all stream infiltration areas; restore major subsidence area; restore selected strip mines in addition to those covered by Plan III; construct impermeable seal below the ground surface in selected portions of the Study Area including the Browns Run watershed, the northern extremity of the Sulfur Run watershed and the watershed of certain wet weather streams tributary to Sulfur Run

Estimated AMD Reductions Attributable to Preventive Measures

Volume - 49%
Iron tonnage - 52%
Acid tonnage - 52%

Treatment Measures - All AMD remaining after construction of Preventive Measures

Abatement Plan V

Preventive Measures - Construct impermeable seal on the ground surface of that portion of the Study Area which could contribute ground water to deep mine workings; reconstruct stream channels, fill major subsidence area, move all Refuse material, and backfill all strip mines to accommodate construction of impermeable seal

Estimated AMD Reductions Attributable to Preventive Measures
Volume - 100%
Iron tonnage - 100%
Acid tonnage - 100%

Treatment Measures - None

Collection Systems required in connection with Abatement Plans I, II, III and IV include, among other things, a flow equalization basin, conveyance sewers and open channels. For cost estimating purposes, the flow equalization basin was designed for Design Maximum AMD Volumes from all MD discharge points; conveyance sewers and open channels also were designed on the basis of Design Maximum Volumes. All AMD discharges would flow by gravity to conveyance sewers and open channels. To accommodate construction of open channels along Sulfur Run and its northeast tributary, portions of these streams would be relocated. The portions of Sulfur Run and its northeast tributary to be relocated are designated as FF' and GG' on Plate IV (Winburne). Treatment plants for Abatement Plans I, II III and IV were sized on the basis of Design Wet Weather Volumes.

Cost Estimates For AMD Abatement Plans Studied in Detail

A summary of costs associated with each Winburne Abatement Plan studied in detail for purposes of this report is presented in the following:

		Total Annual Costs		
	Project Cost	Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Plan I	$ 3,500,000	$ 561,400	$456,200	$466,900
Plan II	3,870,000	559,800	427,600	440,600
Plan III	5,614,000	662,300	394,800	421,550
Plan IV	14,149,000	1,067,500	278,800	357,700
Plan V	41,400,000	2,647,000	492,600	708,000

Discussion of AMD Abatement Plans Studied in Detail

A discussion of various factors important in evaluating Abatement Plans studied in detail for the Winburne Study Area is presented in the following:

Abatement Plan I

Project as well as initial thirty year Total Annual Costs for Plans I and II would for all practical purposes be equal and less than for the other plans studied in detail. Plan I however, with increased time, would be the most costly of all plans with the exception of Plan V. Since Plan I contemplates treating all Winburne Study Area AMD at one location, all Treatment Measures included in Plan I would have to be constructed in one step before any reductions in AMD pollution would be realized from Plan I.

Abatement Plan II

Although Project as well as initial thirty year Total Annual Costs for Plan II would be less than for Plans III, IV, and V, Plan II with increased time would be more costly than Plans III and IV. Plan II Project Costs could be extended over several years by stage construction of the Preventive Measures comprising the plan. After constructing each Preventive Measure, its impact on AMD reductions could subsequently be measured and subsequent Abatement Measures planned on the basis of this experience.

Stage construction of Preventive Measures would also enable a given appropriation to be used in several areas affected by AMD, thereby benefiting each area on a continuous basis. In addition to eliminating AMD pollution, local aesthetic benefits would be realized from Plan II.

Abatement Plan III

Plan III possesses the same advantages as does Plan II insofar as the stage construction of Preventive Measures is concerned. Greater AMD reductions from Preventive Measures would be realized from Plan III than Plan II. Plan III would probably be more costly than Plan II initially but with increased time less costly. Local aesthetic benefits would also be realized from Plan III.

Abatement Plan IV

Plan IV possesses the same advantages as do Plans II and III insofar as the stage construction of Preventive Measures and local aesthetic benefits are concerned. Although this plan promises the greatest reductions in AMD pollution from Preventive Measures and would be least costly over extended periods of time, Initial Costs would be considerably greater than for Plans I, II, and III.

Abatement Plan V

Both Initial and Long Term Costs for Plan V would be considerably greater than for the other plans. The only benefit to be realized from this greater cost would be the complete elimination of AMD pollution in the Study Area regardless of the extent of precipitation. While construction of an impermeable seal appears to be the only Preventive Measure capable of completely eliminating AMD in the Study Area, it would for all practical purposes render useless for farming, timbering, etc. the land over which applied unless some auxiliary benefit could be obtained. Furthermore, it appears that a substantial portion of the impermeable seal would have to be constructed before any significant AMD reductions would be realized from Plan V.

Recommended AMD Abatement Plan

Plans II and III offer certain cost advantages over other plans studied in detail for the Winburne Study Area. Although Initial Costs would be greater than for Plan II, Plan III is recommended for implementation due to lower Long Term Costs. Although Long Term Costs for Plan IV would be less than for Plan III, Plan IV is not recommended because of its high Project Cost. The recommended order for constructing Preventive Measures comprising Abatement Plan III is set forth in the following:

Reconstruct stream channels in stream infiltration areas AA' through DD' and restore strip mine S-6 (Use Refuse to meet partial fill requirement)
Restore major subsidence area, reconstruct stream channel in stream infiltration area EE', and restore strip mines S-13, S-20 and S-21 (Use Refuse to meet partial fill requirement)
Restore strip mines S-4, S-5, S-7, S-8, S-9 and S-10 (Use Refuse to meet partial fill requirement)

Upon completing construction of all Preventive Measures comprising Plan III, Treatment Measures to the extent required by then existing SWB MD discharge limitations can subsequently be provided. Project and unit cost information for the Preventive and Treatment Measures comprising recommended Abatement Plan III is summarized in the following:

		Total Annual Costs Per Ton Of Acid Removed		
	Project Cost	Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Preventive Measures	$2,872,000	$ 116	$ 2.39	$13.80
Treatment Measure	2,742,000	63.50	53.50	54.50

Noted on Plate IV (Winburne) are the locations of the various Abatement Measures comprising recommended Abatement Plan III. For each MD discharge point covered by the FWPCA gauging, sampling and analytical program, there are presented on Exhibit H (Winburne) estimates of AMD volumes, constituents and characteristics subsequent to construction of recommended Preventive Measures comprising Abatement Plan III. For the recommended Preventive and Treatment Measure comprising Abatement Plan III, there is presented on Exhibit I (Winburne) pertinent cost and other information.

EXHIBIT B (Winburne)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Subsidence Areas

Subsidence Area (1)	Affected Area (Acres)	Coal Seam Into Which Overburden Has Subsided	MD Discharge Point With Which Subsided Area Communicates (1)
B-1	20	Lower Kittanning	3, 4, 5, 6, 7

(1) Refer to Plate II (Winburne)

EXHIBIT C (Winburne)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Stream Infiltration Areas

Infiltration Area (1)	Length (Feet)	Coal Seam Into Which Stream Flows Infiltrate	MD Discharge Point With Which Infiltration Area Communicates (1)
AA'	1,900	Lower Kittanning	11, 12
BB'	1,300	Lower Kittanning	11, 12
CC'	1,600	Lower Kittanning	11, 12
DD'	3,800	Lower Kittanning	11, 12
EE'	2,000	Lower Kittanning	3, 4, 5, 6, 7

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(1) Refer to Plate II (Winburne)

EXHIBIT E (Winburne)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of MD Discharge Points

Discharge Point (1)	Type Of Mine, and Coal Seam From Which MD Discharges	Type Of Discharge
1	Deep mine in Lower Kittanning seam	Gravity flow through ditch in intercepting strip mine; continuous, augmented by seasonal surface water infiltration
2	Deep mine in Lower Kittanning seam	Gravity flow through partially caved drift; continuous, augmented by seasonal surface water infiltration
3	Deep mine in Lower Kittanning seam	Gravity flow through Refuse area from deep mine workings; continuous, augmented by seasonal surface water infiltration
4	Deep mine in Lower Kittanning seam	Gravity flow through open drift; continuous, augmented by seasonal surface water infiltration
5	Deep mine in Lower Kittanning seam	Gravity flow through intercepting strip mine; continuous, augmented by seasonal surface water infiltration
6	Deep mine in Lower Kittanning seam	Artesian flow through fractured rock strata in intercepting strip mine; continuous, augmented by seasonal surface water infiltration

EXHIBIT E (Winburne Continued)
Page Two

Discharge Point (1)	Type Of Mine, And Coal Seam From Which MD Discharges	Type Of Discharge
7	Deep mine in Lower Kittanning seam	Gravity flow through rock strata adjacent to deep mine; continuous, augmented by seasonal surface water infiltration
8	Deep mine in Lower Kittanning seam	Gravity flow through intact mine seal; continuous, augmented by seasonal surface water infiltration
9	Deep mine in Lower Kittanning seam	Gravity flow through intact mine seal; continuous, augmented by seasonal surface water infiltration
10	Deep mine in Lower Kittanning seam	Gravity flow through caved, possibly sealed, drift; intermittent, fluctuates with surface water infiltration
11	Deep mine in Lower Kittanning seam	Gravity flow through partially caved drift; continuous, augmented by seasonal surface water infiltration
12	Deep mine in Lower Kittanning seam	Artesian flow from caved drift through fractured rock strata; continuous, augmented by seasonal surface water infiltration
13	Deep mine in Lower Kittanning seam	Gravity flow through tile pipe from intact mine seal; continuous, augmented by seasonal surface water infiltration

(1) Refer to Plate II (Winburne)

EXHIBIT F (Winburne)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Calculations And Assumptions For Total Study Area Design MD Volumes

Design Average MD Volume

Estimated total average yearly precipitation in the Study Area and vicinity over the period of record (1) = 42 inches or 0.00479 in./hr

Study Area acreage = 3,919

Runoff coefficient
Study Area = 0.05

Forty-five (45) per cent of the total precipitation on the Study Area assumed lost to the atmosphere by evaporation and transpiration

Precipitation on the Study Area infiltrating to underground workings - Total available precipitation

$$42\,\frac{\text{in.}}{\text{year}} \times 3{,}919\text{ acres} \times 43{,}560\,\frac{\text{sq ft}}{\text{acre}} \times \frac{1\text{ ft}}{12\text{ in.}} \times 7.48\,\frac{\text{gal}}{\text{cu ft}} \times \frac{1\text{ year}}{365\text{ days}}$$

12.2 mgd

Losses

Surface water runoff directly to surface streams

$$0.05 \times 0.00479\,\frac{\text{in.}}{\text{hr}} \times 3{,}919\text{ acres} \times 0.646\,\frac{\text{mgd}}{\text{cfs}}$$

0.6 mgd

Evaporation and transpiration

$$\frac{45}{100} \times 12.2\text{ mgd}$$

5.5 mgd

EXHIBIT F (Winburne Continued)
Page Two

Infiltration to underground workings
6.1 mgd

Design average volume (total precipitation discharged from Study Area underground workings as MD)
6.1 mgd

Design Wet Weather MD Volume

Estimated total average precipitation in the Study Area and vicinity from December through April over the period of record (1)	15.4 inches
Conditions during gauging, sampling and analytical program (2) -	
AMD volume during high ground water level period	12.85 mgd
Estimated total precipitation in the Study Area and vicinity (1)	13 inches
Precipitation deficiency	15.6 %
Design wet weather volume (total precipitation discharged from Study Area underground workings as MD)	14.9 mgd

Design Maximum MD Volume

Estimated total 24 hour accumulation of rainfall that will occur no more frequently than once every 10 years = 4.09 inches or 0.17 in./hr

Study Area acreage = 3,919

Runoff coefficient
Study Area = 0.08

Forty-five (45) per cent of the total rainfall on the Study Area assumed lost to the atmosphere by evaporation and transpiration

Rainfall on the Study Area infiltrating to underground workings -

Total available rainfall

$$4.09\,\frac{\text{in.}}{\text{day}} \times 3{,}919\ \text{acres} \times 43{,}560\,\frac{\text{sq ft}}{\text{acre}} \times \frac{1\ \text{ft}}{12\ \text{in.}} \times 7.48\,\frac{\text{gal}}{\text{cu ft}}$$

434 mgd

Losses

Surface water runoff directly to surface streams

$$0.08 \times 0.17\,\frac{\text{in.}}{\text{hr}} \times 3{,}919\ \text{acres} \times 0.646\,\frac{\text{mgd}}{\text{cfs}}$$

35 mgd

Evaporation and transpiration

$$\frac{45}{100} \times 434\ \text{mgd}$$

195 mgd

Infiltration to underground workings

204 mgd

Design maximum volume (total rainfall discharged from Study Area underground workings as MD)

204 mgd

(1) As equivalent inches of rainfall
(2) December 1966 through April 1967

APPENDIX B

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Evaluation Of AMD Abatement Measures

I. Preventive Measures

	Inundate Deep Mine Workings	Reconstruct Stream Channels	Construct Surface Water Diversion Ditches
Purpose	Eliminate atmospheric oxygen contact with acid producing material	Eliminate stream discharge to deep mine workings	Convey surface waters around or across strip mine or around deep mine opening to a water course
General Construction Procedure	Seal to extent necessary to inundate	Place liner in existing stream channel	Construct diversion ditch on uphill side of strip mine or around deep mine opening
Anticipated AMD Reduction Assuming Proper Construction And Maintenance			
Volume	None after inundation occurs	Stream volume prevented from entering the mine	Surface waters captured in ditch
Iron and Acid Concentration	After initial increase, a significant reduction	None	None
Extent Of Experience With Measures			
Construction	Limited	Extensive	Extensive
Maintenance Performed	None	Extensive to none	Extensive
Data Accumulated On Effectiveness	Limited	Limited	Limited
Performance Of Measures Constructed	As anticipated	As anticipated	As anticipated
Comments	Most effective when inactive workings are completely inundated; limited applicability in areas where overburden is heavily fissured; inundation of some deep mines below gravity drainage points has occurred after mine drainage pumping has ceased	In some instances a new channel may be excavated in lieu of lining existing channel	

	Restore Strip Mines	Move Refuse Into Strip Mines	Cover Refuse Material
Purpose	Induce runoff rather than impoundment of surface waters and direct precipitation	Reduce number of AMD discharge points	Eliminate Refuse AMD discharge
General Construction Procedure	Backfill strip mine with Refuse and other earthen material to desired grade	Move Refuse from ground surface into strip mines	Prepare Refuse area and cover with impermeable material; construct surface water diversion ditch uphill from Refuse
Anticipated AMD Reduction Assuming Proper Construction And Maintenance			
Volume	Surface waters and direct precipitation, captured prior to construction, less normal filtration	None	Discharge eliminated
Iron and Acid Concentration	None	None	--
Extent Of Experience With Measures			
Construction	Extensive	Limited	Extensive
Maintenance Performed	Limited to none	None	Extensive
Data Accumulated on Effectiveness	Limited	None	Limited
Performance Of Measures Constructed	Some as anticipated; some not as anticipated	No data available	As anticipated
Comments	Past limited success has been caused by variance in backfilling practice; elimination of AMD discharges from strip mines, and reduction of AMD from Refuse are potential benefits	Only benefit realized is elimination of Refuse AMD discharge points	Refuse can be moved into strip mine and covered, or covered in place; spontaneous combustion possible if precautions not taken

	Excavate And Restore Subsidence Areas	Close Deep Mine Entries	Construct Impermeable Seal On Ground Surface
Purpose	Induce runoff rather than impoundment of surface waters and direct precipitation	Prevent discharge of surface waters and direct precipitation to deep mine workings	Eliminate AMD discharges by preventing infiltration to deep mine workings
General Construction Procedure	Excavate subsidence area and backfill with earthen material	Place seal in deep mine entries	Prepare ground surface and place asphaltic covering
Anticipated AMD Reduction Assuming Proper Construction And Maintenance			
Volume	Surface waters and direct precipitation captured prior to construction, less normal infiltration	Surface waters and direct precipitation tributary to entries	Discharges eliminated
Iron and Acid Concentration	None	None	--
Extent Of Experience With Measures			
Construction	Limited	Extensive	None
Maintenance Performed	None	Limited to none	None
Data Accumulated On Effectiveness	None	None	None
Performance Of Measures Constructed	No data available	No data available	No data available
Comments	In certain instances, backfilling and restoration is all that may be required	The primary benefit of the Works Progress Administration's air sealing program was the reduction of AMD volumes	To be effective, impermeable seal must be used where ground water migration through deep mine workings does not exist; considerable preparatory work must be done prior to placing impermeable seal

	Construct Barriers In Deep Mine Workings	Construct Impermeable Seal Below Ground Surface
Purpose	Inundate portions of deep mine workings to eliminate atmospheric oxygen contact with acid producing material, and/or divert mine flows into areas where there will be less contact with acid producing material	Eliminate AMD discharges by preventing infiltration to deep mine workings
General Construction Procedure	Seal existing deep mine water flow routes	Prepare and place bentonite layer approximately four feet below ground surface
Anticipated AMD Reduction Assuming Proper Construction And Maintenance		
Volume	None	Discharges eliminated
Iron and Acid Concentration	After initial increase, a significant reduction	--
Extent Of Experience With Measures		
Construction	Extensive	None
Maintenance Performed	Extensive	None
Data Accumulated on Effectiveness	Limited	None
Performance Of Measures Constructed	Some as anticipated; some not as anticipated	No data available
Comments	Past limited success due to doubtful condition of barriers; extensive preparatory work necessary to insure safe working conditions	To be effective, impermeable seal must be used where ground water migration through deep mine workings does not exist; fault in seal difficult to locate

	Air Seal Deep Mine Workings	Apply Surface Sealant To Acid Producing Materials In Deep Mine Workings	Lower Ground Water Table
Purpose	Eliminate atmospheric oxygen contact with acid producing material	Eliminate atmospheric oxygen and water contact with acid producing material	Eliminate ground water migration into deep mine workings
General Construction Procedure	Seal all openings into deep mine workings to prevent inflow of air	Prepare, and place impermeable sealant on acid producing material	Drill boreholes and install deep well pumps for pumping ground water to the surface
Anticipated AMD Reduction Assuming Proper Construction And Maintenance			
Volume	Some reduction in volume can be anticipated	None	Ground water prevented from entering deep mine workings
Iron and Acid Concentration	Complete	Complete	None
Extent Of Experience With Measures			
Construction	Extensive	Limited	None
Maintenance Performed	Limited to none	Limited to none	None
Data Accumulated on Effectiveness	Limited	Limited	None
Performance Of Measures Constructed	Not as anticipated	Not as anticipated	No data available
Comments	Past limited success due to difficulty in sealing all openings, fissures, etc. through which air can enter deep mine workings, and poor maintenance; changes in atmospheric pressure inside and outside of the deep mine workings can also cause atmospheric oxygen entry into deep mine workings	Past limited success due to difficulty in placing and maintaining seal; extensive preparatory work in deep mine workings necessary to increase safe working conditions	Most effective if used at the start of deep mining; will not eliminate infiltration through overburden

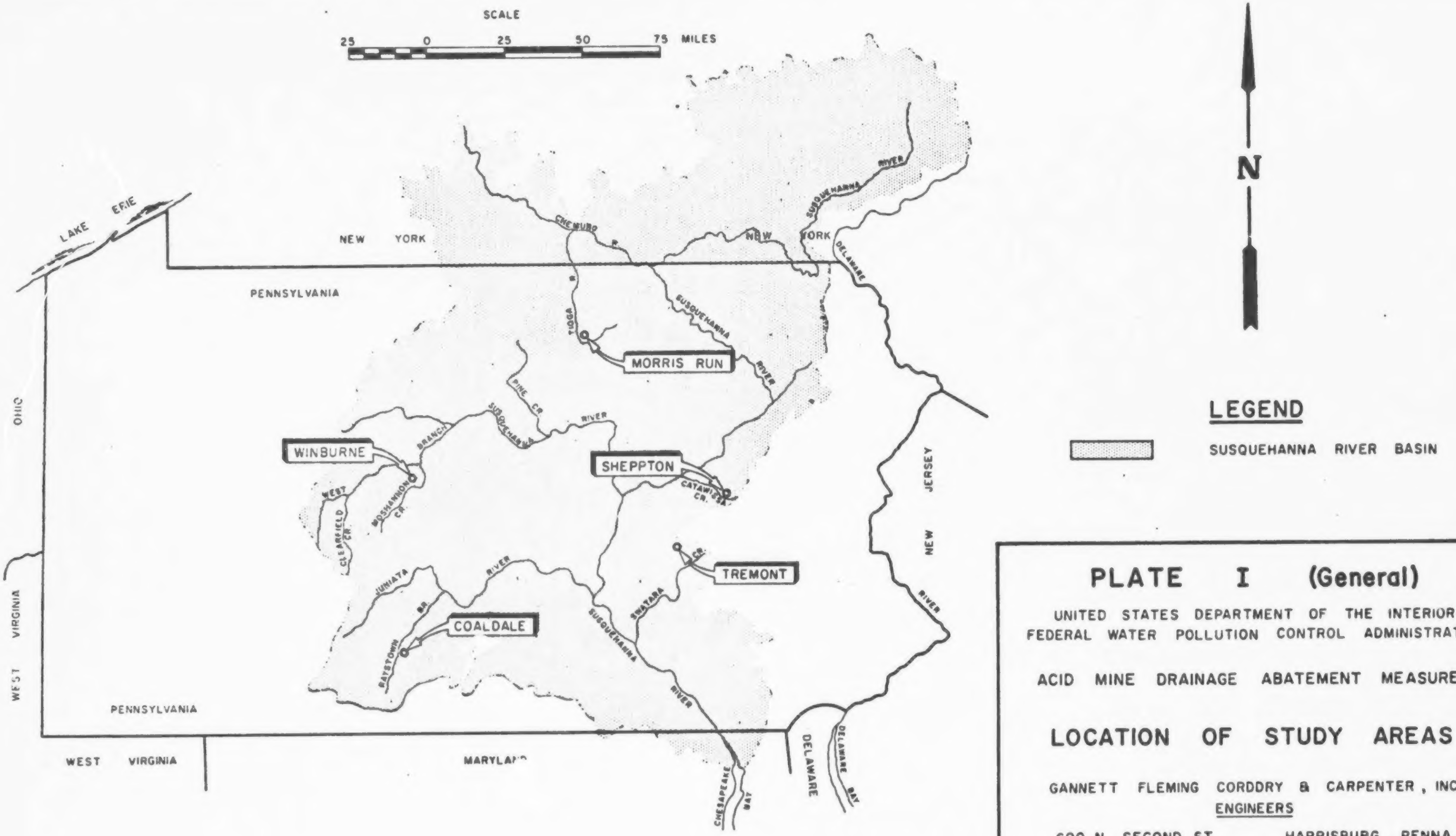
	Collapse Deep Mine Workings	Displace Air In Deep Mine Workings	Place Bacteriophage In Deep Mine Workings
Purpose	Raise ground water table and inundate deep mine workings to eliminate atmospheric oxygen contact with acid producing material; reduce infiltration to deep mine workings	Eliminate atmospheric oxygen contact with acid producing material	Inhibit or eliminate action of iron oxidizing bacteria
General Construction Procedure	Use explosives to collapse overburden into deep mine workings; regrade and plant	Seal all openings and pump inert gas into deep mine workings	Introduce bacteriophage into mine water pools and flow routes
Anticipated AMD Reduction Assuming Proper Construction And Maintenance			
Volume	Surface waters and direct precipitation captured prior to construction, less normal infiltration	None	None
Iron and Acid Concentration	After initial increase, a significant reduction	Complete	Complete
Extent Of Experience With Measures			
Construction	None	Limited	None
Maintenance Performed	None	Limited	None
Data Accumulated on Effectiveness	None	Extensive	None
Performance Of Measures Constructed	No data available	Not as anticipated	No data available
Comments	Presents hazard to existing subsurface utilities; extensive preparatory work necessary	Past limited success due to difficulty in sealing all openings, fissures, etc., and displacing air from all portions of deep mine workings	Still in developmental stage

II. Treatment Measures

	Demineralize	Chemically Neutralize And Oxidize In Treatment Facilities	Chemically Neutralize In Underground Mine Water Pools
Anticipated AMD Reduction Assuming Proper Construction, Operation And Maintenance			
Volume	None	None	None
Iron and Acid Concentration	To SWB MD discharge limitations, or better	To SWB MD discharge limitations	To SWB MD discharge limitations
Extent Of Experience With Measures			
Construction	Limited	Extensive	None
Maintenance Performed	Extensive	Extensive to none	None
Data Accumulated on Effectiveness	Limited	Extensive to limited	None
Performance Of Measures Constructed	As anticipated	Some as anticipated; some not as anticipated	No data available
Comments	Includes electrodialysis, distillation, ion exchange and reverse osmosis; generally still in developmental stage; has potential of producing extremely high quality effluent	Past limited success due to improper design, operation and/or maintenance	Extensive subsurface information needed; generally limited to pools wherein iron concentration is below 7 mg/l

III. Disposal Measures

	Deep Well Injection	Controlled Discharge To Surface Streams	Spray On Ground Surface
Purpose	Inject AMD into underground geological formation with no connection to surface streams	Regulate AMD discharge to surface streams to minimize pollutional effects	Utilize absorptive, evaporative and transpirative capacity of soil and its cover to prevent reentry of AMD to deep mine workings, and surface runoff
General Construction Procedure	Drill wells and install pumps to inject AMD into underground geological formations	Construct AMD flow regulation facilities such as holding lagoons, and/or boreholes and deep well pumps in pools; stream flow regulation facilities such as dams may also be necessary	Provide pumping, conveyance, and spray facilities necessary for applying AMD to ground surface
Extent Of Experience With Measures			
Construction	None	Limited	None
Maintenance Performed	None	Limited to none	None
Data Accumulated on Effectiveness	None	Limited	None
Performance Of Measures Constructed	No data available	As anticipated	No data available
Comments	Extensive subsurface information needed; solids plugging of strata needs further investigation; previous experience limited to industrial wastewaters other than AMD	After treatment of AMD discharges to meet current SWB MD discharge limitations, stream flow regulation could be utilized for quality control purposes	Pilot testing needed to obtain information and data concerning design, operation and maintenance


SCALE
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LEGEND
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CHESAPEAKE BAY
CHEMUNG R.
TIOGA R.
SUSQUEHANNA RIVER
DELAWARE RIVER
PINE CR.
WEST BRANCH SUSQUEHANNA RIVER
MOSHANNON CR.
WEST CLEARFIELD CR.
JUNIATA RIVER
RAYSTOWN BR.
SWATARA CR.
CATAWISSA CR.
MORRIS RUN
WINBURNE
SHEPPTON
TREMONT
COALDALE

PLATE I (General)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

LOCATION OF STUDY AREAS

GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.

AUGUST 1967

EXHIBIT A (Morris Run)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Deep Mine Entries

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-1	Slope	Lower Kittanning	--	X	Caved, no underground workings exposed	5
D-2	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-1 (1)	5
D-3	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed, stripped by S-3 (1)	5
D-4	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	5
D-5	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	5
D-6	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	1, 2
D-7	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	1, 2
D-8	Drift	Lower Kittanning	--	X	Open, underground workings exposed, partially flooded, driven into highwall of S-6 (1)	5

EXHIBIT A (Morris Run Continued)
Page Two

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-9	Drift	Lower Freeport	--	X	Open, underground workings exposed, partially flooded, stripped by S-9 (1)	5
D-10	Drift	Lower Freeport	--	X	Caved, no underground workings exposed	1, 2
D-11	Drift	Middle Kittanning	--	X	Partially caved, underground workings exposed	1, 2
D-12	Drift	Lower Kittanning	--	X	Five openings, all caved, no underground workings exposed	1, 2
D-13	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, AMD discharge point 2 (1)	2
D-14	Drift	Lower Kittanning	--	X	Four openings, all partially caved, underground workings exposed	5
D-15	Drift	Upper Kittanning	--	X	Caved, no underground workings exposed, stripped by S-10 (1)	5
D-16	Drift	Upper Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-10 (1)	5
D-17	Drift	Upper Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-10 (1)	5
D-18	Drift	Lower Kittanning	--	X	Three openings, all caved, no underground workings exposed	5

EXHIBIT A (Morris Run Continued)
Page Three

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-19	Drift	Middle Kittanning	--	X	Caved, no underground workings exposed	5
D-20	Drift	Brookville	--	X	Caved, no underground workings exposed	4
D-21	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	5
D-22	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	5
D-23	Drift	Middle Kittanning	--	X	Caved, no underground workings exposed	5
D-24	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	5
D-25	Drift	Middle Kittanning	--	X	Caved, no underground workings exposed	5
D-26	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	5
D-27	Drift	Brookville	--	X	Caved, no underground workings exposed	4
D-28	Drift	Brookville	--	X	Caved, no underground workings exposed	4
D-29	Drift	Brookville	--	X	Partially caved, underground workings exposed, AMD discharge point 4 (1)	4

EXHIBIT A (Morris Run Continued)
Page Four

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-30	Drift	Brookville	--	X	Caved, no underground workings exposed	4
D-31	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, AMD discharge point 5 (1)	5
D-32	Drift	Lower Kittanning	--	X	Three openings, all caved, no underground workings exposed	5
D-33	Drift	Middle Kittanning	--	X	Caved, no underground workings exposed	5
D-34	Drift	Upper Freeport	--	X	Open, underground workings exposed, partially flooded, driven into highwall of S-15 (1)	5
D-35	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed, partially flooded, stripped by S-15 (1)	5
D-36	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed, partially flooded, stripped by S-15 (1)	5
D-37	Drift	Upper Freeport	--	X	Open, underground workings exposed, driven into highwall of S-17 (1)	5

EXHIBIT A (Morris Run Continued)
Page Five

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine: Active	Current Status Of Mine: Inactive	Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
D-38	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed, stripped by S-23 (1)	5
D-39	Drift	Lower Kittanning	--	X	Open, underground workings exposed, driven into highwall of S-23 (1)	5
D-40	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	5
D-41	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	10
D-42	Drift	Lower Freeport	--	X	Partially caved, underground workings exposed, driven into highwall of S-27 (1)	5
D-43	Drift	Lower Freeport	--	X	Partially caved, underground workings exposed, driven into highwall of S-27 (1)	5
D-44	Drift	Lower Freeport	--	X	Partially caved, underground workings exposed, driven into highwall of S-27 (1), discharge from entry enters borehole into underlying underground workings	5
D-45	Drift	Lower Freeport	--	X	Partially caved, underground workings exposed, partially flooded, stripped by S-29 (1), AMD discharge point 11 (1)	11
D-46	Drift	Lower Kittanning	--	X	Open, underground workings exposed, AMD discharge point 10 (1)	10

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine Active	Current Status Of Mine Inactive	Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
D-47	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed, stripped by S-28 (1)	5
D-48	Shaft	Lower Kittanning	--	X	Filled, no underground workings exposed, stripped by S-28 (1)	5
D-49	Drift	Middle Kittanning	--	X	Caved, no underground workings exposed, stripped by S-28 (1)	5
D-50	Drift	Upper Kittanning	--	X	Caved, no underground workings exposed	5
D-51	Drift	Upper Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-20 (1), AMD discharge point 6 (1)	6, 5
D-52	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	5
D-53	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, AMD discharge point 14 (1)	14
D-54	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, AMD discharge point 15 (1)	15
D-55	Drift	Upper Kittanning	--	X	Open, underground workings exposed	15
D-56	Drift	Upper Kittanning	--	X	Open, underground workings exposed	15
D-57	Drift	Upper Kittanning	--	X	Open, underground workings exposed	15

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-58	Drift	Upper Kittanning	--	X	Open, underground workings exposed	15
D-59	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-41 (1), AMD discharge point 16 (1)	16
D-60	Drift	Lower Kittanning	--	X	Open, underground workings exposed, driven into highwall of S-41 (1)	16
D-61	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed, stripped by S-22 (1)	5
D-62	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	10
D-63	Drift	Lower Kittanning	--	X	Two openings, both caved, no underground workings exposed	10
D-64	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, driven into highwall of S-37 (1)	10, 14
D-65	Slope	Lower Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-37 (1)	10, 14
D-66	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-11 (1)	5
D-67	Drift	Upper Kittanning	--	X	Caved, no underground workings exposed	5
D-68	Drift	Upper Kittanning	--	X	Caved, no underground workings exposed	5
D-69	Drift	Monkey	--	X	Caved, no underground workings exposed	10

EXHIBIT A (Morris Run Continued)
Page Seven

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-58	Drift	Upper Kittanning	--	X	Open, underground workings exposed	15
D-59	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-41 (1), AMD discharge point 16 (1)	16
D-60	Drift	Lower Kittanning	--	X	Open, underground workings exposed, driven into highwall of S-41 (1)	16
D-61	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed, stripped by S-22 (1)	5
D-62	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	10
D-63	Drift	Lower Kittanning	--	X	Two openings, both caved, no underground workings exposed	10
D-64	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, driven into highwall of S-37 (1)	10, 14
D-65	Slope	Lower Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-37 (1)	10, 14
D-66	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-11 (1)	5
D-67	Drift	Upper Kittanning	--	X	Caved, no underground workings exposed	5
D-68	Drift	Upper Kittanning	--	X	Caved, no underground workings exposed	5
D-69	Drift	Monkey	--	X	Caved, no underground workings exposed	10

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-70	Drift	Upper Kittanning	--	X	Caved, no underground workings exposed	14
D-71	Drift	Lower Freeport	--	X	Caved, no underground workings exposed	14
D-72	Drift	Lower Freeport	--	X	Caved, no underground workings exposed, stripped by S-30 (1)	10, 11

(1) Refer to Plate II (Morris Run)

EXHIBIT D (Morris Pun)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Strip Mines

		Current Status Of Mine			Strip Pit			Type Of Interconnection With Deep Mine Workings		
Strip Mine (1)	Coal Seam Stripped	Active	Inactive	Affected Acreage	Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	MD Discharge Point With Which Strip Mine Communicates (1)
S-1	Lower Kittanning	--	X	1.7	600	0	None	X	--	5
S-2	Upper Kittanning	--	X	4.9	900	225 675	None Sloped to highwall	--	X	5
S-3	Lower Kittanning	--	X	7.7	2,100	1,050 1,050	None Sloped to highwall	X	--	1, 2, 5
S-4	Lower Kittanning	--	X	9.0	1,000	300 700	None Sloped to highwall	X	--	1, 2
S-5	Lower Freeport	--	X	20.2	2,900	0	None	--	X	5
S-6	Lower Freeport	--	X	49.8	2,300	1,730 570	None Sloped to highwall	--	X	1, 2, 3, 5
S-7	Lower Freeport, Upper Freeport	X	--	110.8	5,000	Active	Contour backfilled to date	--	X	5
S-8	Upper Freeport	--	X	11.8	900	0	None	--	X	5

EXHIBIT D (Morris Run Continued)
Page Two

		Current Status Of Mine			Strip Pit			Type Of Interconnection With Deep Mine Workings		
Strip Mine (1)	Coal Seam Stripped	Active	Inactive	Affected Acreage	Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	MD Discharge Point With Which Strip Mine Communicates (1)
S-9	Lower Freeport	--	X	11.1	1,400	700 700	None Sloped to highwall	X	--	5
S-10	Upper Kittanning	--	X	7.7	2,300	0	None	X	--	5
S-11	Lower Kittanning	--	X	8.4	2,200	2,200	Sloped to highwall	--	X	5
S-12	Lower Freeport	--	X	4.5	600	0	None	--	X	5
S-13	Lower Freeport	--	X	3.5	500	0	None	--	X	5
S-14	Lower Freeport	--	X	29.6	2,500	250 2,250	Contour None	--	X	5
S-15	Upper Freeport	--	X	16.0	2,500	0	None	X	--	5
S-16	Upper Freeport	--	X	10.1	1,400	1,400	Sloped to highwall	--	X	7, 5
S-17	Upper Freeport	--	X	5.9	1,600	0	None	X	--	5
S-18	Lower Freeport	--	X	10.8	1,300	1,300	Sloped to highwall	--	X	5
S-19	Lower Freeport	--	X	36.6	3,300	330 2,970	Contour None	--	X	7, 5
S-20	Upper Kittanning	--	X	1.0	400	0	None	X	--	6, 5
S-21	Lower Freeport	--	X	1.0	600	0	None	--	X	5
S-22	Lower Kittanning	--	X	34.1	6,300	6,300	Sloped to highwall	X	--	5

		Current Status Of Mine			Strip Pit			Type Of Interconnection With Deep Mine Workings		
Strip Mine (1)	Coal Seam Stripped	Active	Inactive	Affected Acreage	Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	MD Discharge Point With Which Strip Mine Communicates (1)
S-23	Lower Kittanning	--	X	53.9	3,900	1,950 780 1,170	Contour Sloped to highwall None	X	--	5
S-24	Lower Kittanning	--	X	3.5	800	0	None	X	--	5
S-25	Lower Kittanning	--	X	1.7	700	0	None	X	--	5
S-26	Lower Kittanning	--	X	10.1	1,500	1,125 375	Sloped to highwall None	--	X	5
S-27	Lower Freeport	--	X	29.2	2,400	1,200 1,200	Sloped to highwall None	X	--	5, 9
S-28	Lower Kittanning, Middle Kittanning	--	X	27.9	3,300	0	None	X	--	5
S-29	Lower Freeport	--	X	8.4	1,500	0	None	X	--	11
S-30	Lower Freeport	--	X	1.4	400	400	Pasture	X	--	10, 11
S-31	Lower Freeport	--	X	2.1	600	0	None	--	X	10, 11
S-32	Lower Kittanning	--	X	1.7	400	0	None	--	--	--
S-33	Lower Kittanning	--	X	10.4	2,600	2,600	Sloped to highwall	X	--	10
S-34	Lower Freeport	--	X	10.8	2,300	2,300	Sloped to highwall	--	X	13
S-35	Lower Freeport	--	X	32.7	3,200	0	None	--	X	12

EXHIBIT D (Morris Run Continued)
Page Four

		Current Status Of Mine			Strip Pit			Type Of Interconnection With Deep Mine Workings		
Strip Mine (1)	Coal Seam Stripped	Active	Inactive	Affected Acreage	Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	MD Discharge Point With Which Strip Mine Communicates (1)
S-36	Lower Freeport	--	X	42.2	2,900	870 2,030	Contour None	--	X	10, 11
S-37	Lower Kittanning, Freak, Middle Kittanning	--	X	52.3	2,700	2,430 270	Sloped to highwall None	X	--	10, 14
S-38	Lower Freeport	--	X	20.2	1,300	1,300	Sloped to highwall	--	X	14
S-39	Lower Kittanning, Middle Kittanning, Freak, Upper Kittanning, Monkey, Lower Freeport	X	--	301.0	7,600	Active	Contour backfilled to date	X	--	14, 15
S-40	Lower Kittanning	--	X	10.1	1,800	1,800	Sloped to highwall	--	X	14, 15
S-41	Brookville, Lower Kittanning	--	X	41.5	6,500	3,250 3,250	Sloped to highwall None	X	--	16

(1) Refer to Plate II (Morris Run)

EXHIBIT G (Morris Run)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Design MD Volumes, Constituents And Characteristics At Each Discharge Point

	Design Average						Design Wet Weather						Design Maximum					
			Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3	
Dis-charge Point(1)	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day
1	1.181	2.8-3.0	55	.271	480	2.362	2.650	3.0-3.2	25	.278	275	3.038	46.080	3.5-3.9	10	1.910	110	21.100
2	.173	2.8-3.0	30	.022	415	.299	.259	2.9-3.1	15	.016	130	.255	4.608	3.6-3.9	5	.077	70	1.350
3	.115	4.3-4.8	Tr.	.001	30	.016	.173	4.5-5.2	Tr.	.001	30	.020	3.067	3.7-6.0	Tr.	--	10	.077
4	.216	2.8-3.0	115	.102	560	.500	.331	2.9-3.0	80	.112	450	.645	5.761	3.2-3.9	10	.240	220	5.300
5	5.724	2.8-2.9	90	2.100	645	15.375	11.434	2.8-3.0	65	3.035	485	23.100	196.704	3.0-3.8	30	24.500	350	287.250
6	.115	3.4-4.4	Tr.	.001	60	.029	.187	3.3-4.4	Tr.	.001	50	.040	3.456	3.7-5.0	Tr.	--	10	.145
7	.086	3.0-3.2	35	.013	840	.303	.173	3.0-3.2	25	.016	750	.535	3.067	3.0-3.8	10	.102	480	6.150
8	.058	3.0-3.6	5	.001	440	.106	.115	2.9-3.4	5	.002	400	.190	1.915	3.2-3.9	Tr.	.008	170	1.365
9	.022	2.7-3.0	130	.011	1,300	.117	.043	2.7-3.1	120	.019	1,200	.190	.763	2.9-3.6	15	.045	820	2.610
10	1.584	3.0-3.6	30	.213	310	2.065	3.413	3.1-3.5	20	.285	295	4.190	58.723	3.2-3.8	10	1.970	210	51.600
11	.058	2.9-3.3	10	.002	295	.071	.115	3.0-3.4	5	.004	270	.128	1.915	3.2-3.9	Tr.	.016	180	1.440
12	.086	2.9-3.4	325	.117	2,350	.845	.173	3.0-3.5	160	.115	1,585	1.130	3.067	2.9-3.6	30	.385	750	9.650
13	.072	2.9-3.3	290	.087	2,200	.660	.158	2.9-3.4	225	.142	1,400	.885	2.693	3.0-3.6	40	.445	700	7.835
14	.720	2.7-3.1	205	.612	2,240	6.725	1.872	2.8-3.1	160	1.265	1,400	11.100	32.645	2.9-3.6	110	15.425	700	95.200
15	.216	2.8-3.1	55	.050	650	.585	.893	2.8-3.2	20	.084	395	1.510	16.128	2.9-3.7	10	.535	340	20.350
16	.086	3.1-3.4	15	.005	350	.126	.187	3.1-3.4	15	.009	250	.200	3.456	3.2-3.8	10	.102	110	1.585

(1) Refer to Plate II (Morris Run)

EXHIBIT H (Morris Run)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Estimated AMD Volumes, Constituents And Characteristics Remaining At Each Discharge Point After Construction Of All Recommended Preventive Measures

	Design Average						Design Wet Weather						Design Maximum					
			Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3	
Discharge Point(1)	Total Daily Volume (MG)	pH Range	mg/l	Tons/Day	mg/l	Tons/Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/Day	mg/l	Tons/Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/Day	mg/l	Tons/Day
1	.880	2.8-3.0	55	.202	480	1.761	2.040	3.0-3.2	25	.213	275	2.339	35.595	3.5-3.9	10	1.484	110	16.327
2	.173	2.8-3.0	30	.022	415	.299	.259	2.9-3.1	15	.016	130	.140	4.608	3.6-3.9	5	.077	70	1.350
3	.112	4.3-4.8	Tr.	.001	30	.014	.166	4.5-5.2	Tr.	.001	30	.019	2.992	3.7-6.0	Tr.	--	10	.075
4	.214	2.8-3.0	115	.103	560	.499	.324	2.9-3.0	80	.110	450	.632	5.621	3.2-3.9	10	.234	220	5.170
5	4.280	2.8-2.9	90	1.606	645	11.500	8.809	2.8-3.0	65	2.340	485	17.600	152.477	3.0-3.8	30	19.080	350	222.800
6	.114	3.4-4.4	Tr.	.001	60	.029	.183	3.3-4.4	Tr.	.001	50	.039	3.372	3.7-5.0	Tr.	--	10	.142
7	.000	--	--	--	--	--	.000	--	--	--	--	--	.000	--	--	--	--	--
8	.000	--	--	--	--	--	.000	--	--	--	--	--	.000	--	--	--	--	--
9	.000	--	--	--	--	--	.000	--	--	--	--	--	.000	--	--	--	--	--
10	1.535	3.0-3.6	30	.192	310	1.984	3.303	3.1-3.5	20	.276	295	4.060	56.410	3.2-3.8	10	1.900	210	49.500
11	.000	--	--	--	--	--	.000	--	--	--	--	--	.000	--	--	--	--	--
12	.000	--	--	--	--	--	.000	--	--	--	--	--	.000	--	--	--	--	--
13	.000	--	--	--	--	--	.000	--	--	--	--	--	.000	--	--	--	--	--
14	.695	2.7-3.1	205	.594	2240	6.491	1.811	2.8-3.1	160	1.223	1400	10.740	31.357	2.9-3.6	110	14.820	700	91.500
15	.210	2.8-3.1	55	.048	650	.569	.875	2.8-3.2	20	.082	395	1.480	15.734	2.9-3.7	10	.522	340	19.850
16	.085	3.1-3.4	15	.005	350	.124	.183	3.1-3.4	15	.009	250	.196	3.372	3.2-3.8	10	.100	110	1.545

(1) Refer to Plate II (Morris Run)

EXHIBIT I (Morris Run)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Pertinent Design and Cost Data for Recommended Abatement Plan

	Estimated AMD Reduction(1)				Average Annual Costs for Initial Thirty Years(1)			Average Annual Costs for Next Two Hundred Seventy Years(1)			Costs For Three Hundred Years (1)	
	Volume (mgd)	Iron (Tons/ Day)	Acid (Tons/ Day)	Project Cost	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Fixed	Operation and Maintenance	Per Ton of Acid Removed	Per Ton of Acid Removed	Total
Preventive Measures												
Reconstruct stream channels in all stream infiltration areas; 4,300 ft	1.50	0.47	3.85	$ 49,000	$ 2,800	$ 450	$ 2.31	$1,270	$ 450	$ 1.22	$ 1.33	$ 561,900
Excavate and restore all major subsidence areas; 43 acres, 1,000,000 cu yds of material to be moved	0.04	0.01	0.10	1,200,000	69,400	1,400	1,940	None	None	None	194	2,124,000
Construct surface water diversion ditches at strip mines S-4, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 22, 24, 25, 28, 31, 33, 37, 40 and 41; 44,100 ft	0.14	0.05	0.42	54,000	3,100	10,350	88	None	10,350	67.50	69.40	3,198,000
Restore strip mines S-3, 14, 26, 27, 29, 34, 35 and 36; 178 acres, 2,600,000 cu yds of fill (Refuse used to meet partial fill requirements)	0.42	0.25	2.54	2,447,000	141,500	11,000	164	None	None	None	16.45	4,575,000
Subtotal	2.10	0.78	6.91	3,750,000	216,000	23,200	95.20	1,270	10,800	4.80	13.70	10,458,900

EXHIBIT I (Morris Run Continued)
Page Two

	Estimated AMD Reduction(1)				Average Annual Costs for Initial Thirty Years(1)			Average Annual Costs for Next Two Hundred Seventy Years(1)			Costs For Three Hundred Years(1)	
Treatment Measure	Volume (mgd)	Iron (Tons/ Day)	Acid (Tons/ Day)	Project Cost	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Fixed	Operation and Maintenance	Per Ton of Acid Removed	Per Ton of Acid Removed	Total
Collection System 1,950 ft of open channel; 7 flow equalization basins; 36,209 ft of conveyance sewers from 6 to 36 in. diameter; relocate 2,700 ft of stream channel	--	--	--	$1,999,000	$115,400	$ 51,800	--	$25,700	$ 51,550	--	--	$ 25,873,500
Treatment Facilities	--	2.4(2)	23.3(3)	1,020,000	59,200	274,800	--	59,200	275,000	--	--	100,254,000
Subtotal	--	2.4	23.3	3,019,000	174,600	326,600	58.90	84,900	326,550	48.40	49.40	126,127,500
Total	2.10	3.2	30.2	6,769,000	391,400	349,000	67.40	86,170	337,500	38.40	41.30	136,586,400

(1) Calculated on basis of design average conditions
(2) To 7 mg/l
(3) To 0 mg/l as $CaCO_3$

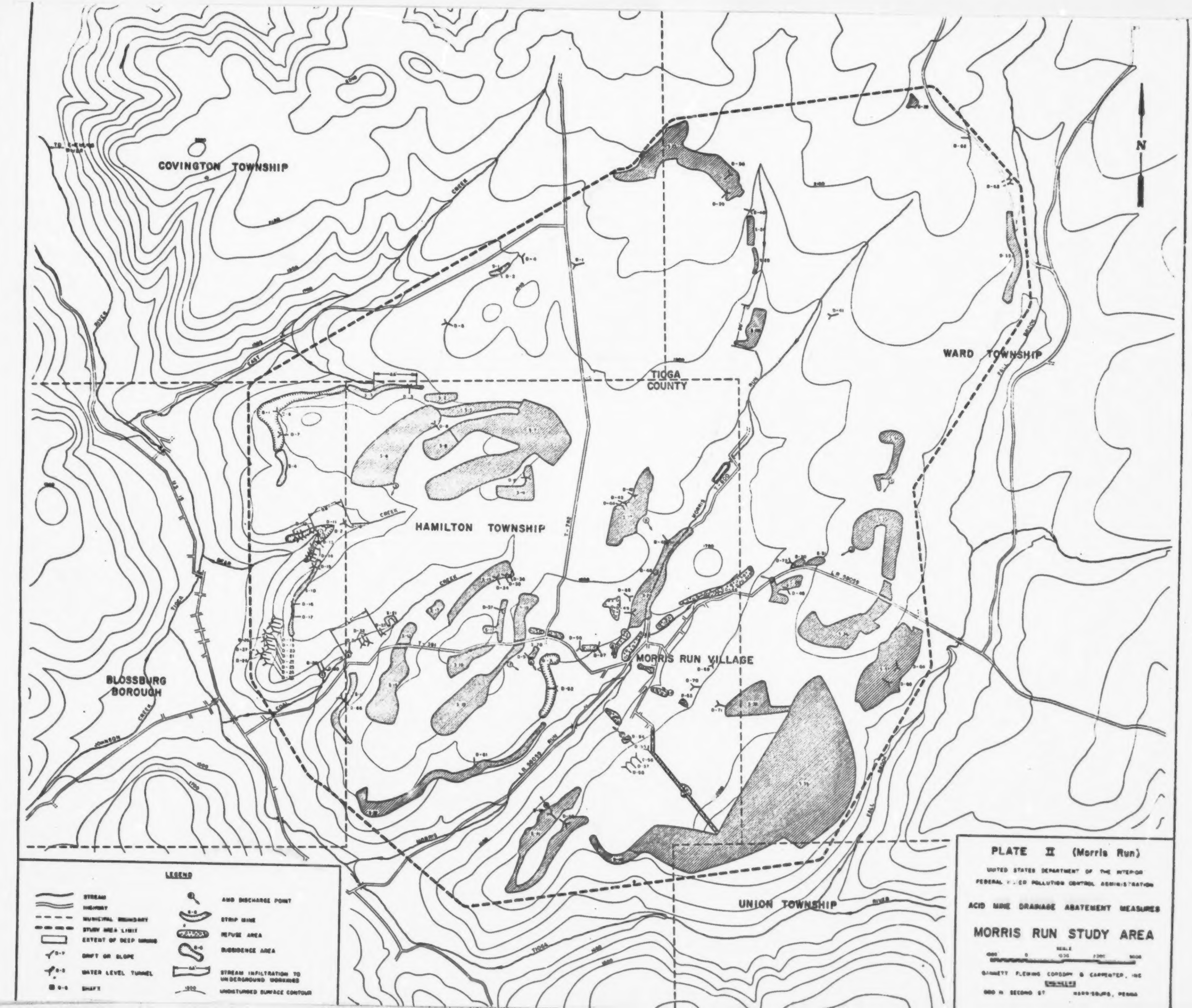

N
COVINGTON TOWNSHIP
WARD TOWNSHIP
TIOGA COUNTY
HAMILTON TOWNSHIP
MORRIS RUN VILLAGE
BLOSSBURG BOROUGH
UNION TOWNSHIP
MORRIS RUN
CREEK
TIOGA RIVER
JOHNSON CREEK
L.R. 58039
T-391
T-792
LEGEND
STREAM
HIGHWAY
MUNICIPAL BOUNDARY
STUDY AREA LIMIT
EXTENT OF DEEP MINING
DRIFT OR SLOPE
WATER LEVEL TUNNEL
SHAFT
AMD DISCHARGE POINT
STRIP MINE
REFUSE AREA
SUBSIDENCE AREA
STREAM INFILTRATION TO UNDERGROUND WORKINGS
UNDISTURBED SURFACE CONTOUR

PLATE II (Morris Run)

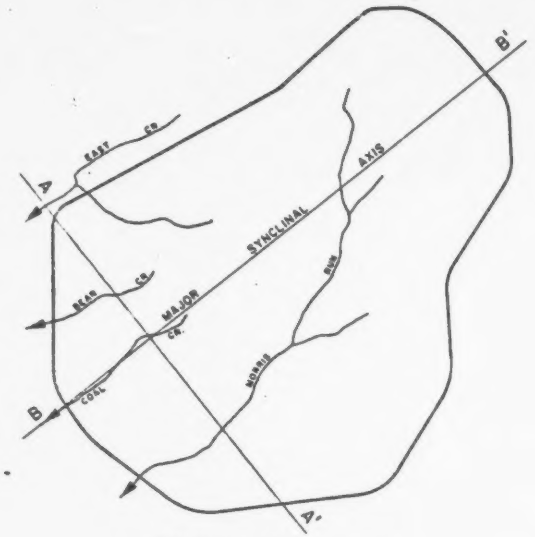
UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

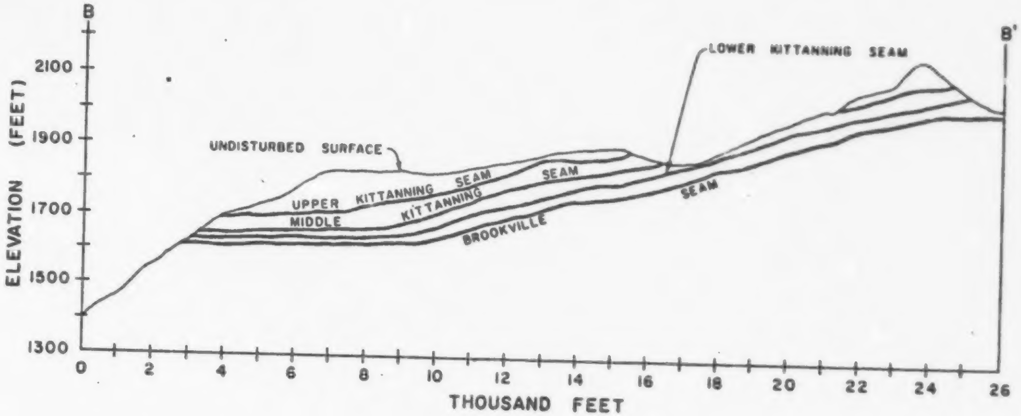
MORRIS RUN STUDY AREA

SCALE
1000 0 1000 2000 3000

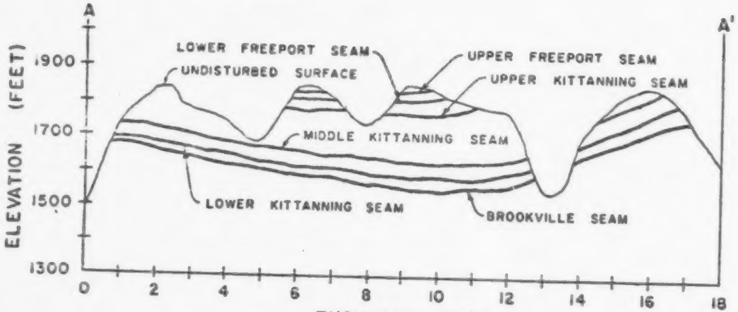
GANNETT FLEMING CORDDRY & CARPENTER, INC
600 N. SECOND ST HARRISBURG, PENNA


A
B'
B
A'
EAST CR.
BEAR CR.
MAJOR CR.
COAL
SYNCLINAL AXIS
RUN
MORRIS

STUDY AREA PLAN
SCALE 1" = 5000'


B
B'
ELEVATION (FEET)
2100
1900
1700
1500
1300
0
2
4
6
8
10
12
14
16
18
20
22
24
26
THOUSAND FEET
LOWER KITTANNING SEAM
UNDISTURBED SURFACE
UPPER KITTANNING SEAM
MIDDLE KITTANNING SEAM
BROOKVILLE SEAM

SECTION B - B'


A
A'
ELEVATION (FEET)
1900
1700
1500
1300
0
2
4
6
8
10
12
14
16
18
THOUSAND FEET
LOWER FREEPORT SEAM
UNDISTURBED SURFACE
UPPER FREEPORT SEAM
UPPER KITTANNING SEAM
MIDDLE KITTANNING SEAM
LOWER KITTANNING SEAM
BROOKVILLE SEAM

SECTION A - A'

NOTE: FOOT, FREAK AND MONKEY SEAMS, LOCATED ABOVE THE LOWER KITTANNING, MIDDLE KITTANNING AND UPPER KITTANNING SEAMS RESPECTIVELY, ARE FOUND INTERMITTENTLY THROUGHOUT THE STUDY AREA. BASED ON INFORMATION CURRENTLY AVAILABLE, THE EXTENT OF THESE SEAMS, WHEN THEY EXIST, IS NOT WELL DEFINED.

PLATE III (Morris Run)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

MORRIS RUN COAL SEAMS

GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.

AUGUST 1967

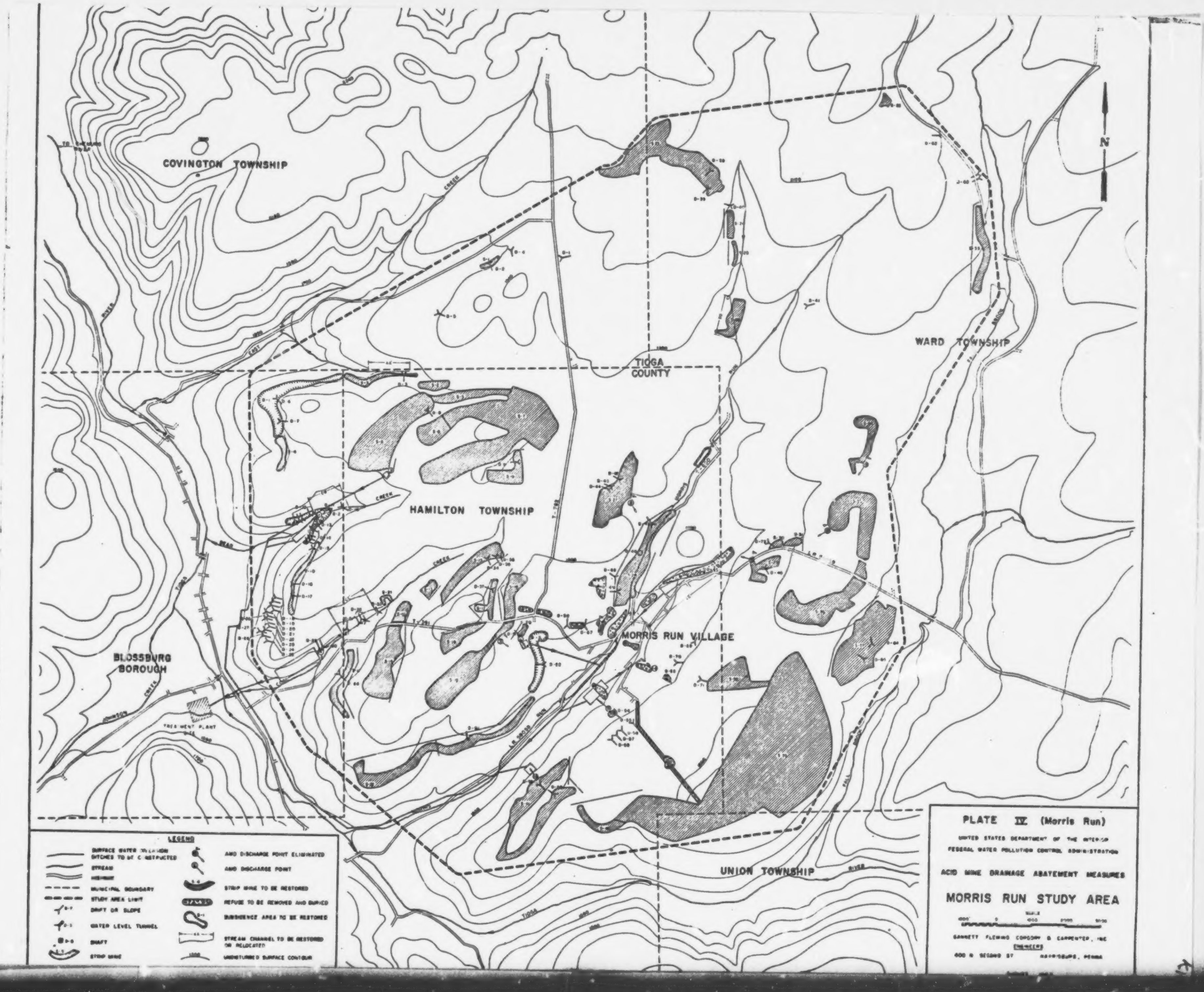

N
COVINGTON TOWNSHIP
WARD TOWNSHIP
TIOGA COUNTY
HAMILTON TOWNSHIP
MORRIS RUN VILLAGE
BLOSSBURG BOROUGH
UNION TOWNSHIP
TREATMENT PLANT
CREEK
RIVER
LEGEND
SURFACE WATER DIVERSION DITCHES TO BE CONSTRUCTED
STREAM
HIGHWAY
MUNICIPAL BOUNDARY
STUDY AREA LIMIT
DRIFT OR SLOPE
WATER LEVEL TUNNEL
SHAFT
STRIP MINE
AMD DISCHARGE POINT ELIMINATED
AMD DISCHARGE POINT
STRIP MINE TO BE RESTORED
REFUSE TO BE REMOVED AND BURIED
SUBSIDENCE AREA TO BE RESTORED
STREAM CHANNEL TO BE RESTORED OR RELOCATED
UNDISTURBED SURFACE CONTOUR
SCALE

PLATE IV (Morris Run)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

MORRIS RUN STUDY AREA

GANNETT FLEMING CORDDRY & CARPENTER, INC
ENGINEERS
600 N. SECOND ST HARRISBURG, PENNA

EXHIBIT A (Sheppton)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Deep Mine Entries

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-1	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, driven into highwall of S-5 (1)	1
D-2	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, driven into highwall of S-5 (1)	1
D-3	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, stripped by S-5 (1)	1
D-4	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, driven into highwall of S-5 (1)	1
D-5	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, driven into highwall of S-5 (1)	1
D-6	Shaft	All veins	--	X	Open, underground workings exposed, stripped by S-5 (1)	1
D-7	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, stripped by S-1 (1)	1

EXHIBIT A (Sheppton Continued)
Page Two

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-8	Slope	Gamma	--	X	Partially caved, underground workings exposed, driven into highwall of S-5 (1)	1
D-9	Slope	Buck Mountain	--	X	Open, underground workings exposed, driven into highwall of S-5 (1)	1
D-10	Slope	Buck Mountain	--	X	Open, underground workings exposed, driven into highwall of S-5 (1)	1
D-11	Slope	Buck Mountain	--	X	Open, underground workings exposed, driven into highwall of S-5 (1)	1
D-12	Slope	Gamma	--	X	Open, underground workings exposed, driven into highwall of S-5 (1)	1
D-13	Slope	Gamma	--	X	Open, underground workings exposed, driven into highwall of S-5 (1)	1
D-14	Slope	Buck Mountain	--	X	Open, underground workings exposed, driven into highwall of S-5 (1)	1
D-15	Slope	Buck Mountain	--	X	Open, underground workings exposed, stripped by S-5 (1)	1
D-16	Slope	Buck Mountain	--	X	Open, underground workings exposed, stripped by S-5 (1)	1
D-17	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, driven into highwall of S-5 (1)	1

EXHIBIT A (Sheppton Continued)
Page Three

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-18	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, driven into highwall of S-5 (1)	1
D-19	Slope	Buck Mountain	--	X	Open, underground workings exposed, driven into highwall of S-5 (1)	1
D-20	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, stripped by S-4 (1)	1
D-21	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, stripped by S-4 (1)	1
D-22	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, driven into highwall of S-2 (1)	1
D-23	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, driven into highwall of S-2 (1)	1
D-24	Shaft	Little Buck Mountain	--	X	Open, underground workings exposed, concrete cap deteriorated	1
D-25	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, driven into highwall of S-2 (1)	1
D-26	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, stripped by S-1 (1)	2, 3

EXHIBIT A (Sheppton Continued)
Page Four

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-27	Water Level Tunnel	Buck Mountain(2)	--	X	Open, underground workings exposed, AMD discharge point 1 (1)	1
D-28	Water Level Tunnel	Buck Mountain(2)	--	X	Open, underground workings exposed, AMD discharge point 2 (1)	2
D-29	Water Level Tunnel	Buck Mountain(2)	--	X	Open, underground workings exposed, AMD discharge point 3 (1)	3

(1) Refer to Plate II (Sheppton)
(2) First coal vein encountered

EXHIBIT D (Sheppton)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Strip Mines

Strip Mine (1)	Coal Vein Stripped	Current Status Of Mine		Affected Acreage	Strip Pit			Type Of Interconnection With Deep Mine Workings		MD Discharge Point With Which Strip Mine Communicates (1)
		Active	Inactive		Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	
S-1	All veins	X	X	390	14,500	300 14,200	Pasture None	X	--	1, 2, 3, 4
S-2	Buck Mountain	--	X	11	900	900	Sloped to pavement	X	--	1
S-3	Buck Mountain	--	X	10	1,000	1,000	Sloped to pavement	X	--	1
S-4	Buck Mountain	--	X	11	1,100	1,100	Sloped to pavement	X	--	1
S-5	All veins	--	X	395	14,800	0	None	X	--	1

(1) Refer to Plate II (Sheppton)

EXHIBIT G (Sheppton)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Design MD Volumes, Constituents And Characteristics
At Each Discharge Point

	Design Average						Design Wet Weather						Design Maximum					
			Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3				Total Iron		Acid as CaCO3	
Discharge Point(1)	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day
1	4.824	3.6-4.0	Tr.	.020	85	1.685	7.560	3.7-4.0	Tr.	.019	60	1.890	154.080	3.8-4.5	Tr.	.193	30	19.250
2	3.658	3.6-4.2	Tr.	.026	80	1.220	5.429	3.8-4.2	Tr.	.027	60	1.360	111.312	3.8-4.6	Tr.	.138	30	13.900
3	4.824	3.6-4.7	Tr.	.020	75	1.505	7.560	4.4-4.5	Tr.	.015	55	1.735	154.080	4.4-5.2	Tr.	.193	30	19.250
4	.288	4.5-5.7	Tr.	.001	15	.019	.619	4.5-4.9	Tr.	.001	5	.012	12.528	4.8-6.6	Tr.	--	0	--

(1) Refer to Plate II (Sheppton)

EXHIBIT H (Sheppton)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Estimated AMD Volumes, Constituents And Characteristics
Remaining At Each Discharge Point After
Construction Of All Recommended Preventive Measures(1)

	Design Average						Design Wet Weather						Design Maximum					
			Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3	
Discharge Point(2)	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day
1	.00	----	----	----	----	----	.00	----	----	----	----	----	.00	----	----	----	----	----
2	.00	----	----	----	----	----	.00	----	----	----	----	----	.00	----	----	----	----	----
3	.00	----	----	----	----	----	.00	----	----	----	----	----	.00	----	----	----	----	----
4	.00	----	----	----	----	----	.00	----	----	----	----	----	.00	----	----	----	----	----
(3)	4.82	4.8-5.6	4	.080	40	.804	7.60	4.8-5.6	3	.095	30	.951	154.08	4.8-5,6	2	1.286	20	12.860
(4)	2.68	4.8-5.6	4	.045	40	.447	4.50	4.8-5.6	3	.056	30	.563	94.52	4.8-5.6	2	.789	20	7.886

(1) Based on pool overflows at stabilized conditions
(2) Refer to Plate II (Sheppton)
(3) New discharge point created in northwestern portion of Study Area
(4) New discharge point created in southeastern portion of Study Area

EXHIBIT I (Sheppton)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Pertinent Design and Cost Data for Recommended Abatement Plan

	Estimated AMD Reduction(1)				Average Annual Costs for Initial Thirty Years(1)			Average Annual Costs for Next Two Hundred Seventy Years(1)			Costs For Three Hundred Years (1)	
	Volume (mgd)	Iron (Tons/ Day)	Acid (Tons/ Day)	Project Cost	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Per Ton Of Acid Removed	Total
Preventive Measures												
Reconstruct Catawissa Creek stream channel, stream infiltration area AA'; 3,000 ft	6.1	0.03	1.88	$ 72,600	$ 4,200	$ 550	$ 6.93	$ 1,600	$ 550	$ 3.14	$ 3.51	$ 723,000
Construct watertight seals in 3 Water Level Tunnels	--	Increase	1.22	300,000	17,400	1,000	41.30	None	1,000	2.24	6.15	822,000
Subtotal	6.1	Increase	3.10	372,600	21,600	1,550	20.40	1,600	1,550	2.78	4.55	1,545,000
Treatment Measure												
Collection System 1,100 ft of open channel; 2 flow equalization basins; 4,100 ft of conveyance sewers from 15 to 24 in. diameter	--	--	--	796,000	46,000	29,400	--	4,500	29,400	--	--	11,408,000
Treatment Facilities	--	None(2)	1.3(3)	787,000	45,500	112,500	--	30,100	74,700	--	--	33,036,000
Subtotal	--	None	1.3	1,583,000	91,500	141,900	492	34,600	104,100	292	312	44,444,000
Total	6.1	Increase	4.4	1,955,600	113,100	143,450	160	36,200	105,650	88.50	95.40	45,989,000

(1) Calculated on basis of design average conditions after the quality of pool overflows would have stabilized
(2) Untreated AMD would have an iron concentration less than 7 mg/l
(3) To 0 mg/l as $CaCO_3$

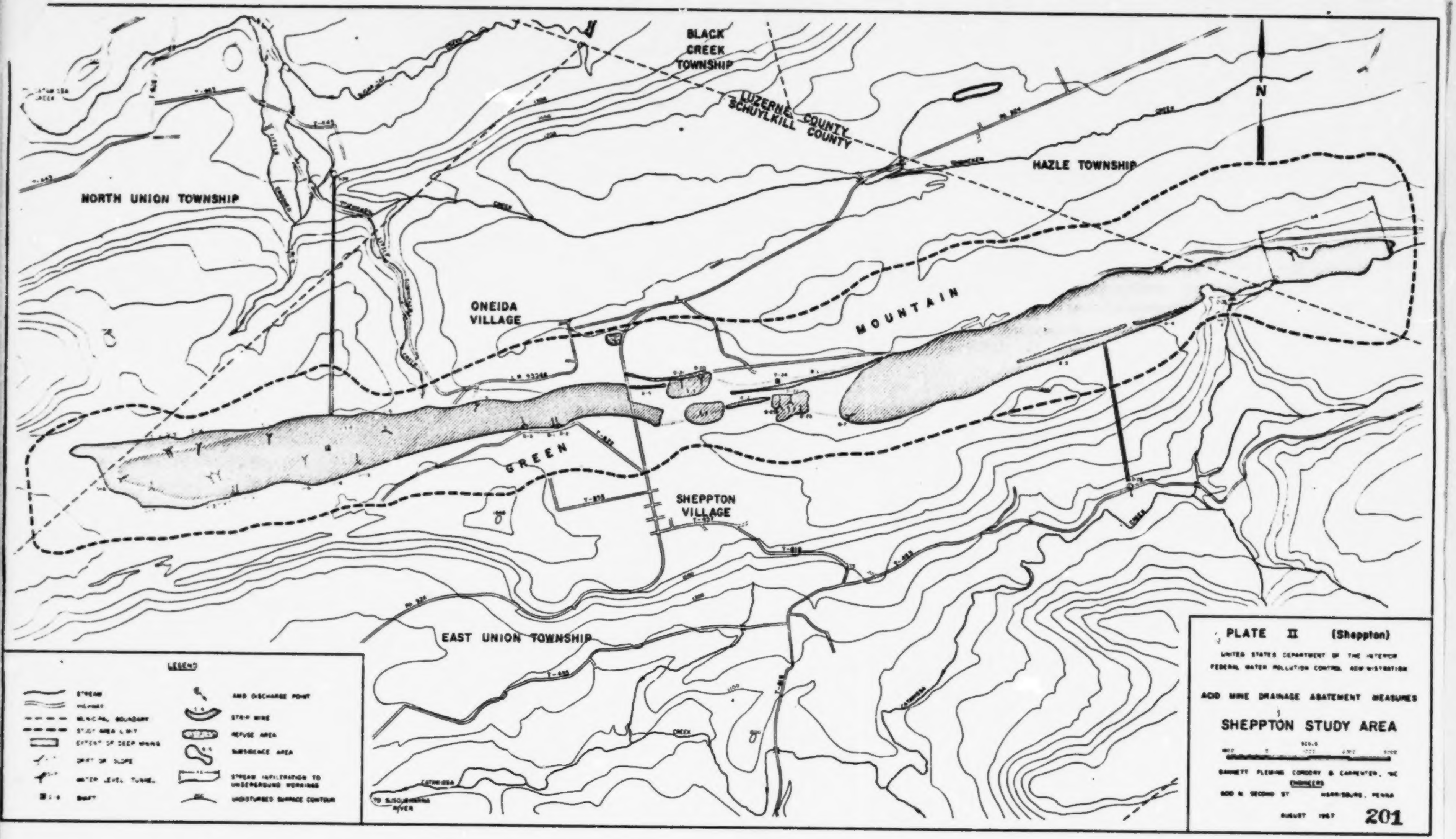

BLACK CREEK TOWNSHIP
LUZERNE COUNTY
SCHUYLKILL COUNTY
HAZLE TOWNSHIP
N
NORTH UNION TOWNSHIP
ONEIDA VILLAGE
MOUNTAIN
GREEN
SHEPPTON VILLAGE
EAST UNION TOWNSHIP
T-443
T-452
T-422
T-873
T-812
T-853
T-850
CREEK
CATAWISSA
TO SUSQUEHANNA RIVER
LEGEND
STREAM
HIGHWAY
MUNICIPAL BOUNDARY
STUDY AREA LIMIT
EXTENT OF DEEP MINING
DRIFT OR SLOPE
WATER LEVEL TUNNEL
SHAFT
AMD DISCHARGE POINT
STRIP MINE
REFUSE AREA
SUBSIDENCE AREA
STREAM INFILTRATION TO UNDERGROUND WORKINGS
UNDISTURBED SURFACE CONTOUR

PLATE II (Sheppton)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

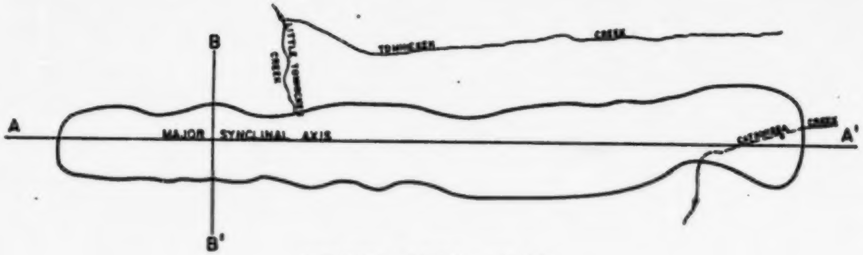
ACID MINE DRAINAGE ABATEMENT MEASURES

SHEPPTON STUDY AREA

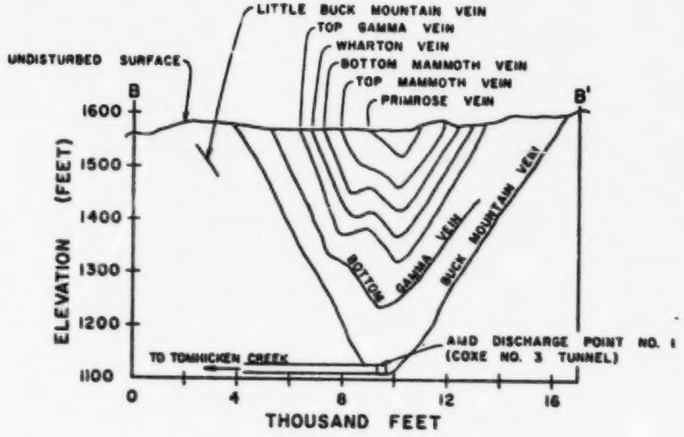
SCALE

GANNETT FLEMING CORDDRY & CARPENTER, INC
ENGINEERS
600 N. SECOND ST HARRISBURG, PENNA

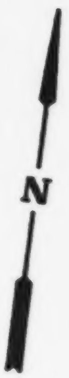
AUGUST 1967 201

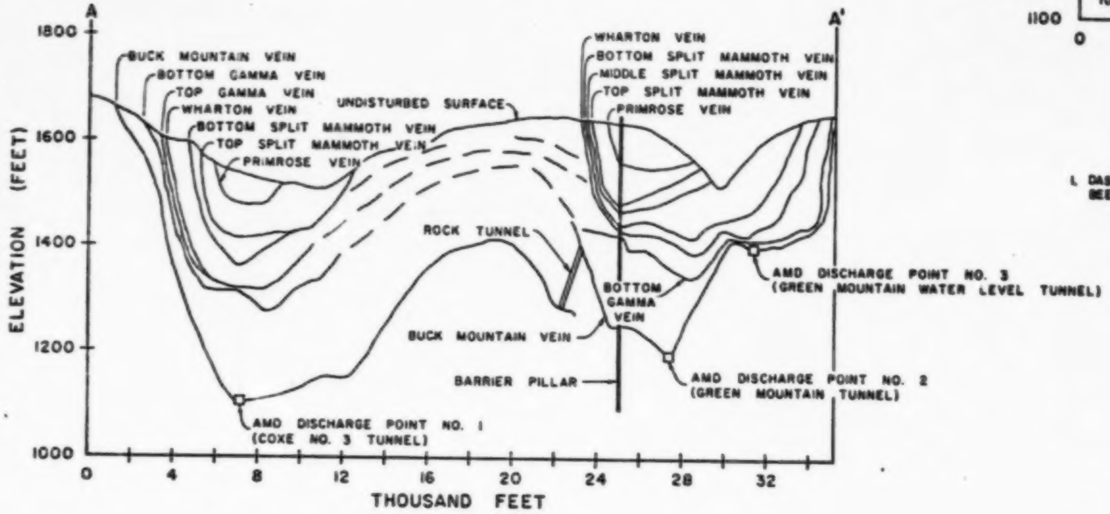

B
LITTLE TOMHICKEN CREEK
TOMHICKEN CREEK
A
MAJOR SYNCLINAL AXIS
CATAWISSA CREEK
A'
B'

STUDY AREA PLAN
SCALE 1" = 5000'


LITTLE BUCK MOUNTAIN VEIN
TOP GAMMA VEIN
WHARTON VEIN
BOTTOM MAMMOTH VEIN
TOP MAMMOTH VEIN
PRIMROSE VEIN
UNDISTURBED SURFACE
B
B'
BOTTOM GAMMA VEIN
BUCK MOUNTAIN VEIN
ELEVATION (FEET)
1600
1500
1400
1300
1200
1100
TO TOMHICKEN CREEK
AMD DISCHARGE POINT NO. 1 (COXE NO. 3 TUNNEL)
0
4
8
12
16
THOUSAND FEET

SECTION B - B'




A
A'
1800
1600
1400
1200
1000
ELEVATION (FEET)
BUCK MOUNTAIN VEIN
BOTTOM GAMMA VEIN
TOP GAMMA VEIN
WHARTON VEIN
BOTTOM SPLIT MAMMOTH VEIN
TOP SPLIT MAMMOTH VEIN
PRIMROSE VEIN
UNDISTURBED SURFACE
ROCK TUNNEL
BUCK MOUNTAIN VEIN
BARRIER PILLAR
AMD DISCHARGE POINT NO. 1 (COXE NO. 3 TUNNEL)
WHARTON VEIN
BOTTOM SPLIT MAMMOTH VEIN
MIDDLE SPLIT MAMMOTH VEIN
TOP SPLIT MAMMOTH VEIN
PRIMROSE VEIN
BOTTOM GAMMA VEIN
AMD DISCHARGE POINT NO. 3 (GREEN MOUNTAIN WATER LEVEL TUNNEL)
AMD DISCHARGE POINT NO. 2 (GREEN MOUNTAIN TUNNEL)
0
4
8
12
16
20
24
28
32
THOUSAND FEET

SECTION A - A'

NOTE

1. DASHED LINES INDICATE AREAS WHERE COAL MEASURES HAVE NOT BEEN PROVEN TO BE CONSISTENTLY PRESENT.

PLATE III (Sheppton)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

SHEPPTON COAL VEINS

GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.

AUGUST 1967

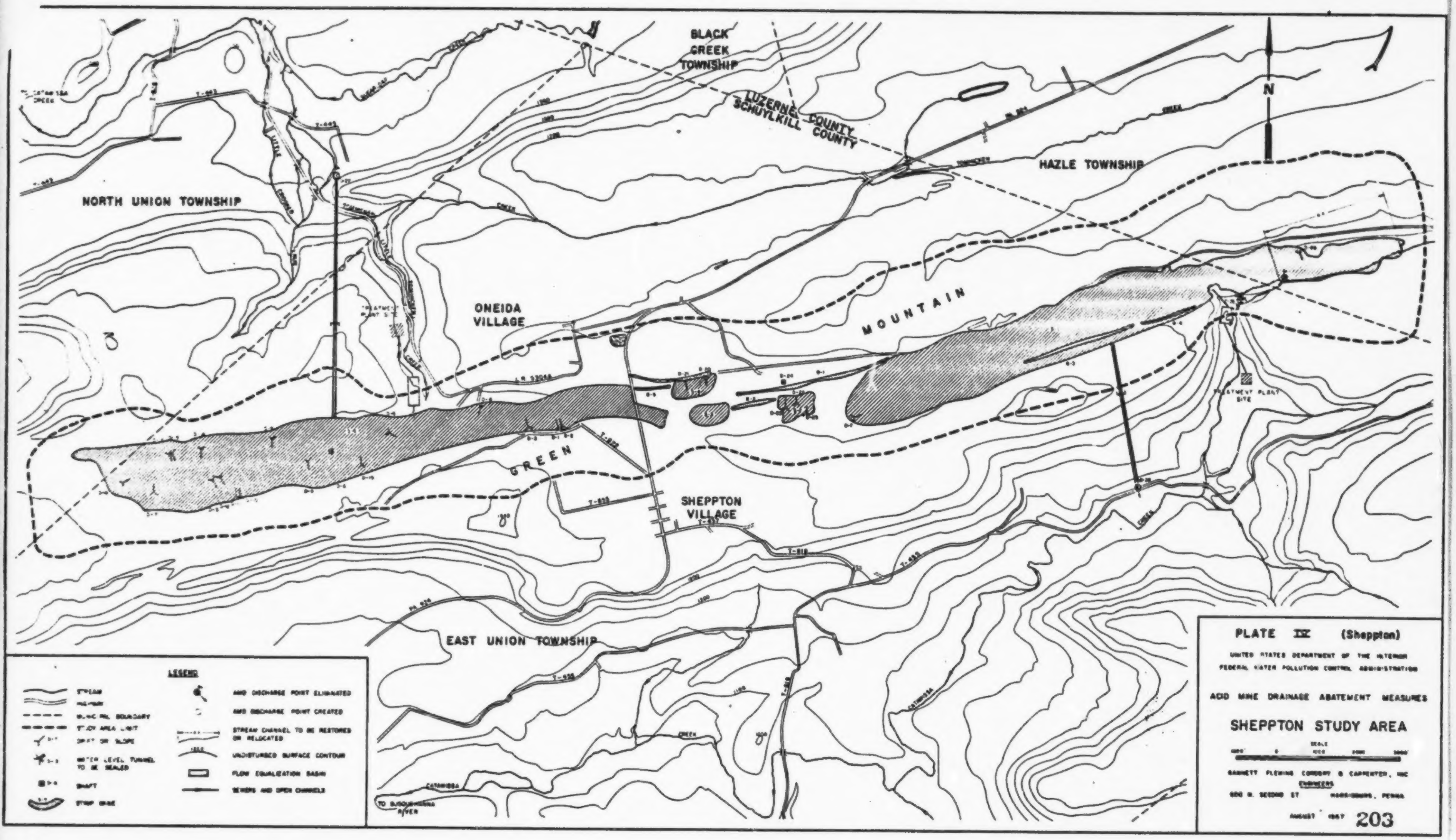

N
BLACK CREEK TOWNSHIP
LUZERNE COUNTY
SCHUYLKILL COUNTY
HAZLE TOWNSHIP
NORTH UNION TOWNSHIP
ONEIDA VILLAGE
MOUNTAIN
GREEN
SHEPPTON VILLAGE
EAST UNION TOWNSHIP
TREATMENT PLANT SITE
TO SUSQUEHANNA RIVER
CATAWISSA
CREEK
T-463
T-820
T-818
T-457
T-458
L.R. 53046
LEGEND
STREAM
HIGHWAY
MUNICIPAL BOUNDARY
STUDY AREA LIMIT
DRIFT OR SLOPE
WATER LEVEL TUNNEL TO BE SEALED
SHAFT
STRIP MINE
AMD DISCHARGE POINT ELIMINATED
AMD DISCHARGE POINT CREATED
STREAM CHANNEL TO BE RESTORED OR RELOCATED
UNDISTURBED SURFACE CONTOUR
FLOW EQUALIZATION BASIN
SEWERS AND OPEN CHANNELS
SCALE
1000 0 1000 2000 3000

PLATE IX (Sheppton)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

SHEPPTON STUDY AREA

GANNETT FLEMING CORDDRY & CARPENTER, INC
ENGINEERS
600 N. SECOND ST HARRISBURG, PENNA

AUGUST 1967

EXHIBIT A (Tremont)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Deep Mine Entries

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-1	Water Level Tunnel	Lykens Valley Nos. 1 & 2	X	--	Open, underground workings exposed, AMD discharge point 6 (1)	6
D-2	Slope	Lykens Valley No. 2	--	X	Partially caved, underground workings exposed, driven into highwall of S-4 (1)	6
D-3	Shaft	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	6
D-4	Slope	Seven Foot	X	--	Open, underground workings exposed, driven into highwall of S-1 (1)	5
D-5	Slope	Primrose	--	X	Partially caved, underground workings exposed, driven into highwall of S-1 (1)	5
D-6	Slope	Seven Foot	X	--	Open, underground workings exposed, driven into highwall of S-1 (1)	5
D-7	Slope	Seven Foot	X	--	Open, underground workings exposed, driven into highwall of S-1 (1)	5

EXHIBIT A (Tremont Continued)
Page Two

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-8	Slope	Diamond	X	--	Open, underground workings exposed	5
D-9	Water Level Tunnel	Lykens Valley Nos. 4 & 5	X	--	Open, underground workings exposed, AMD discharge point 7 (1)	7, 2
D-10	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed, driven into highwall of S-6 (1)	2
D-11	Slope	Tracy	X	--	Open, underground workings exposed, driven into highwall of S-8 (1)	2
D-12	Slope	Clinton	--	X	Partially caved, underground workings exposed, driven into highwall of S-8 (1)	2
D-13	Slope	Clinton	--	X	Partially caved, underground workings exposed, driven into highwall of S-8 (1)	2
D-14	Slope	Primrose	--	X	Partially caved, underground workings exposed, stripped by S-5 (1)	2
D-15	Slope	Clinton	--	X	Partially caved, underground workings exposed, driven into highwall of S-10 (1)	2
D-16	Shaft	Diamond	--	X	Open, underground workings exposed	2

EXHIBIT A (Tremont Continued)
Page Three

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine Active	Current Status Of Mine Inactive	Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
D-17	Slope	Tracy	--	X	Two entries, both open, underground workings exposed, stripped by S-17 (1)	2
D-18	Slope	Primrose	--	X	Partially caved, underground workings exposed, stripped by S-18 (1)	2
D-19	Slope	Orchard	--	X	Partially caved, underground workings exposed, stripped by S-18 (1)	2
D-20	Slope	Mammoth	X	--	Open, underground workings exposed, driven into highwall of S-5a (1)	2
D-21	Slope	Four Foot	X	--	Open, underground workings exposed, driven into highwall of S-5a (1)	2
D-22	Shaft	No. 3	--	X	Open, underground workings exposed, receives all upstream flow of Gebhard Run	3, 4
D-23	Slope	Tunnel	--	X	Partially caved, underground workings exposed, driven into highwall of S-21 (1)	3, 4
D-24	Slope	Clinton	--	X	Partially caved, underground workings exposed, driven into highwall of S-23 (1)	2
D-25	Slope	Clinton	--	X	Partially caved, underground workings exposed, driven into highwall of S-23 (1)	2

EXHIBIT A (Tremont Continued)
Page Four

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine Active	Inactive	Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
D-26	Slope	Primrose	X	--	Open, underground workings exposed, driven into highwall of S-25 (1)	1
D-27	Shaft	Primrose	X	--	Open, underground workings exposed, driven into highwall of S-25 (1)	2
D-28	Slope	Primrose	--	X	Partially caved, underground workings exposed, driven into highwall of S-25 (1)	2
D-29	Slope	Seven Foot	X	--	Open, underground workings exposed, driven into highwall of S-26 (1)	2
D-30	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed	2
D-31	Drift	Buck Mountain	--	X	Partially caved, underground workings exposed	2
D-32	Water Level Tunnel	Buck Mountain	X	--	Open, underground workings exposed, AMD discharge point 1 (1)	1
D-33	Slope	Buck Mountain	--	X	Partially caved, underground workings exposed	1
D-34	Slope	Lykens Valley No. 4	X	--	Open, underground workings exposed	--
D-35	Slope	Lykens Valley No. 4	X	--	Open, underground workings exposed	--

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-36	Slope	Lykens Valley No. 4	--	X	Open, underground workings exposed	7, 2
D-37	Slope	Lykens Valley No. 5	X	--	Open, underground workings exposed	7, 2
D-38	Slope	Lykens Valley No. 5	--	X	Partially caved, underground workings exposed	7, 2
D-39	Slope	Lykens Valley No. 4	--	X	Partially caved, underground workings exposed, stripped by S-33 (1)	7, 2
D-40	Slope	Lykens Valley No. 4	--	X	Partially caved, underground workings exposed	7, 2
D-41	Slope	Lykens Valley No. 5	--	X	Partially caved, underground workings exposed	7, 2
D-42	Slope	Lykens Valley No. 5	--	X	Partially caved, underground workings exposed	7, 2
D-43	Slope	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	7, 2
D-44	Slope	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	7, 2
D-45	Slope	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	7, 2

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine Active	Inactive	Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
D-46	Slope	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	7, 2
D-47	Slope	Lykens Valley No. 4	--	X	Partially caved, underground workings exposed	7,2
D-48	Slope	Lykens Valley No. 5	--	X	Two entries, both partially caved, underground workings exposed	7, 2
D-49	Slope	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	7, 2
D-50	Slope	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	7, 2
D-51	Shaft	Lykens Valley No. 5	X	--	Two entries, both open, underground workings exposed	7, 2
D-52	Slope	Lykens Valley No. 2	--	X	Partially caved, underground workings exposed	7, 2
D-53	Slope	Lykens Valley No. 2	--	X	Partially caved, underground workings exposed	7, 2
D-54	Slope	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	7, 2
D-55	Slope	Lykens Valley No. 5	--	X	Partially caved, underground workings exposed	7, 2
D-56	Slope	Lykens Valley No. 5	--	X	Partially caved, underground workings exposed	7, 2

Deep Mine Entry (1)	Type Of Entry	Coal Vein Mined	Current Status Of Mine Active	Current Status Of Mine Inactive	Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
D-57	Slope	Lykens Valley No. 2	--	X	Partially caved, underground workings exposed	6
D-58	Slope	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	6
D-59	Slope	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	6
D-60	Slope	Lykens Valley No. 2	--	X	Partially caved, underground workings exposed	6
D-61	Slope	Holmes	--	X	Partially caved, underground workings exposed, driven into highwall of S-5a (1)	2
D-62	Slope	Lykens Valley No. 4	--	X	Partially caved, underground workings exposed	7, 2
D-63	Slope	Nos. 3, 4 & 5	--	X	Open, underground workings exposed	3, 4
D-64	Slope	Diamond	X	--	Open, underground workings exposed	5
D-65	Water Level Tunnel	Orchard	--	X	Open, underground workings exposed AMD discharge point 5 (1)	5
D-66	Slope	Lykens Valley No. 3	--	X	Partially caved, underground workings exposed	7, 2

(1) Refer to Plate II (Tremont)

EXHIBIT D (Tremont)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Strip Mines

Strip Mine (1)	Coal Vein Stripped	Current Status Of Mine		Affected Acreage	Strip Pit			Type Of Interconnection With Deep Mine Workings		MD Discharge Point With Which Strip Mine Communicates (1)
		Active	Inactive		Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	
S-1	Orchard through Seven Foot	--	X	109.0	6,200	0	None	X	--	5
S-2	Tracy, Diamond	--	X	16.0	1,700	1,700	Sloped to Pavement	X	--	5
S-3	Tracy, Diamond	--	X	18.1	2,200	2,200	Sloped to pavement	X	--	5
S-4	Lykens Valley Nos. 2 & 3	--	X	24.4	1,700	0	None	X	--	6
S-5	Orchard through Seven Foot	--	X	104.5	5,500	0	None	X	--	5, 2
S-5a	Orchard through Seven Foot	--	X	190.0	6,500	6,500	Sloped to pavement	X	--	2
S-6	Buck Mountain	--	X	18.5	3,500	0	None	X	--	2
S-7	Tracy, Diamond	--	X	7.3	1,200	0	None	X	--	5
S-8	Tracy, Diamond	--	X	37.6	3,000	0	None	X	--	2
S-9	Buck Mountain	--	X	27.5	3,300	0	None	X	--	2
S-10	Tracy, Diamond	--	X	21.9	1,200	0	None	X	--	2

EXHIBIT D (Tremont Continued)
Page Two

Strip Mine (1)	Coal Vein Stripped	Current Status Of Mine		Affected Acreage	Strip Pit			Type Of Interconnection With Deep Mine Workings		MD Discharge Point With Which Strip Mine Communicates (1)
		Active	Inactive		Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	
S-11	Tracy, Clinton	--	X	22.6	2,000	1,700 300	None Sloped to pavement	X	--	2
S-12	No. 4	--	X	8.7	2,000	2,000	Sloped to pavement	X	--	3, 4
S-13	No. 3	--	X	18.5	2,500	2,500	Sloped to pavement	X	--	3, 4
S-14	No. 1	--	X	6.3	1,500	1,500	Sloped to pavement	X	--	3, 4
S-15	No. 1	--	X	8.4	1,800	1,800	Sloped to pavement	X	--	3, 4
S-16	No. 4	--	X	3.5	500	500	Sloped to pavement	X	--	3, 4
S-17	Tracy, Clinton	--	X	20.9	2,000	2,000	Sloped to pavement	X	--	2
S-18	Orchard, Primrose	--	X	12.2	1,600	0	None	X	--	2
S-19	No. 5	--	X	9.1	1,000	0	None	X	--	3, 4
S-20	No. 5	--	X	4.2	600	600	Sloped to pavement	X	--	3, 4
S-21	No. 5	--	X	3.8	500	500	Sloped to pavement	X	--	3, 4
S-22	Little Tracy	--	X	1.7	300	0	None	--	X	3, 4

EXHIBIT D (Tremont Continued)
Page Three

Strip Mine (1)	Coal Vein Stripped	Current Status Of Mine		Affected Acreage	Strip Pit			Type Of Interconnection With Deep Mine Workings		MD Discharge Point With Which Strip Mine Communicates (1)
		Active	Inactive		Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	
S-23	Tracy, Clinton	--	X	27.8	2,700	2,700	Sloped to pavement	X	--	2
S-24	Diamond	--	X	11.2	3,200	0	None	X	--	2
S-25	Primrose	--	X	36.0	3,300	0	None	X	--	2
S-26	Seven Foot	--	X	23.3	3,000	0	None	X	--	2
S-27	Mammoth	--	X	119.7	4,500	4,500	Sloped to pavement	--	X	2
S-28	Buck Mountain, Seven Foot	--	X	25.4	2,000	2,000	Sloped to pavement	X	--	1
S-29	Buck Mountain	--	X	3.1	1,100	0	None	X	--	2
S-30	Buck Mountain	--	X	2.8	900	0	None	X	--	2
S-31	Buck Mountain	--	X	1.0	600	0	None	X	--	5
S-32	Lykens Valley Nos. 4 & 5	--	X	15.3	1,700	850 850	Contour Sloped to pavement	X	--	7, 2
S-33	Lykens Valley Nos. 4 & 5	--	X	8.4	900	900	Sloped to pavement	X	--	7, 2
S-34	Tracy	--	X	15.0	1,900	1,900	Sloped to pavement	--	X	2

EXHIBIT D (Tremont Continued)
Page Four

Strip Mine (1)	Coal Vein Stripped	Current Status Of Mine		Affected Acreage	Strip Pit			Type Of Interconnection With Deep Mine Workings		MD Discharge Point With Which Strip Mine Communicates (1)
		Active	Inactive		Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	
S-35	Primrose	--	X	12.9	1,600	0	None	X	--	2
S-36	Buck Mountain, Mammoth	X	--	57.5	2,500	Active	Partly back-filled to date	X	--	2
S-37	Mammoth	--	X	5.6	900	900	Sloped to pavement	--	X	2
S-38	Mammoth	--	X	3.5	1,000	1,000	Sloped to pavement	--	X	2
S-39	Mammoth	--	X	6.2	1,000	1,000	Sloped to pavement	--	X	2
S-40	Primrose	--	X	2.3	800	0	None	X	--	2
S-41	Diamond	--	X	1.0	400	0	None	X	--	2

(1) Refer to Plate II (Tremont)

EXHIBIT G (Winburne)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Design MD Volumes, Constituents And Characteristics At Each Discharge Point

	Design Average						Design Wet Weather						Design Maximum					
			Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3				Total Iron		Acid as CaCO3	
Discharge Point(1)	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day
1	.137	2.7-3.0	300	.171	1,200	.685	.626	2.6-3.0	240	.633	1,100	2.915	8.568	3.0-3.6	150	5.600	670	24.925
2	.196	2.9-3.1	340	.278	1,200	.979	1.253	2.7-2.9	185	.970	1,050	5.480	17.136	3.0-3.6	140	10.425	970	72.150
3	.003	3.8-4.4	455	.006	730	.009	.014	3.7-4.5	400	.028	700	.050	.202	3.7-4.8	285	.255	630	.560
4	.792	2.9-3.2	225	.745	890	2.940	1.670	2.8-3.2	170	1.185	825	5.725	22.853	3.0-3.8	40	4.190	575	59.375
5	.094	2.9-3.1	100	.038	510	.198	.209	2.9-3.1	65	.058	455	.398	2.851	3.1-3.9	20	.250	370	4.615
6	3.168	2.9-3.2	135	1.780	720	9.480	6.998	2.9-3.2	130	3.855	730	21.400	95.875	3.0-3.8	125	52.850	770	322.500
7	.011	3.0-3.5	200	.010	560	.027	.029	3.0-3.4	185	.022	515	.062	.403	3.1-3.9	75	.138	320	.570
8	.022	3.0-3.4	260	.023	925	.084	.058	2.8-3.4	330	.080	945	.228	.821	3.0-3.7	515	1.760	1,035	3.540
9	.167	2.7-3.0	25	.019	380	.266	.533	2.7-2.9	35	.078	355	.787	7.344	3.1-3.9	40	1.210	330	9.980
10	.000	--	--	--	--	--	.058	2.9-3.1	270	.066	460	.112	.821	3.0-3.9	40	.137	80	.273
11	1.426	2.6-3.1	340	2.035	1,490	8.850	2.995	2.6-3.1	210	2.635	995	12.500	40.795	3.0-3.6	15	2.670	650	115.900
12	.127	2.7-3.2	410	.216	1,450	.765	.317	2.7-3.2	250	.323	820	1.055	4.291	3.0-3.7	30	.562	120	2.260
13	.065	2.7-3.2	80	.021	450	.122	.144	2.8-3.3	30	.018	265	.159	2.045	3.1-3.9	5	.043	20	.172

(1) Refer to Plate II (Winburne)

EXHIBIT H (Winburne)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Estimated AMD Volumes, Constituents And Characteristics
Remaining At Each Discharge Point After
Construction Of All Recommended Preventive Measures

Dis-charge Point(1)	Design Average						Design Wet Weather						Design Maximum					
	Total Daily Volume (MG)	pH Range	Total Iron		Acid-as CaCO3		Total Daily Volume (MG)	pH Range	Total Iron		Acid-as CaCO3		Total Daily Volume (MG)	pH Range	Total Iron		Acid-as CaCO3	
			mg/l	Tons/ Day	mg/l	Tons/ Day			mg/l	Tons/ Day	mg/l	Tons/ Day			mg/l	Tons/ Day	mg/l	Tons/ Day
1	.097	2.7-3.0	300	.121	1,200	.485	.460	2.6-3.0	240	.460	1,100	2.140	6.570	3.0-3.6	150	4.120	670	18.350
2	0.150	2.9-3.1	340	.021	1,200	.750	.986	2.7-2.9	185	.760	1,050	4.320	14.920	3.0-3.6	140	8.710	970	60.400
3	.003	3.8-4.4	455	.006	730	.009	.012	3.7-4.5	400	.020	700	.035	.169	3.7-4.8	285	.201	630	.444
4	.724	2.9-3.2	225	.677	890	2.680	1.463	2.8-3.2	170	1.036	825	5.025	19.080	3.0-3.8	40	3.180	575	45.700
5	.084	2.9-3.1	100	.035	510	.179	.183	2.9-3.1	65	.050	455	.347	2.380	3.1-3.9	20	.198	370	3.670
6	2.900	2.9-3.2	135	1.630	720	8.690	6.124	2.9-3.2	130	3.315	730	18.600	80.000	3.0-3.8	125	41.650	770	257.000
7	.010	3.0-3.5	200	.008	560	.024	.027	3.0-3.4	185	.021	515	.058	.336	3.1-3.9	75	1.105	320	.448
8	.022	3.0-3.4	260	.023	925	.084	.056	2.8-3.4	330	.077	945	.220	.821	3.0-3.7	515	1.760	1,035	3.540
9	.167	2.7-3.0	25	.019	380	.266	.535	2.7-2.9	35	.078	355	.792	7.344	3.1-3.9	40	1.210	330	9.980
10	.000	--	--	--	--	--	.060	2.9-3.1	270	.068	460	.115	.820	3.0-3.9	40	.137	80	.273
11	1.006	2.6-3.1	340	1.420	1,490	6.210	1.972	2.6-3.1	210	1.728	995	18.185	21.920	3.0-3.6	15	1.370	650	59.400
12	.090	2.7-3.2	410	.154	1,450	.544	.210	2.7-3.2	250	.219	820	.718	2.310	3.0-3.7	30	.389	120	1.158
13	.065	2.7-3.2	80	.021	450	.122	.139	2.8-3.3	30	.017	265	.154	2.045	3.1-3.9	5	.043	20	.172

(1) Refer to Plate II (Winburne)

EXHIBIT I (Winburne)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

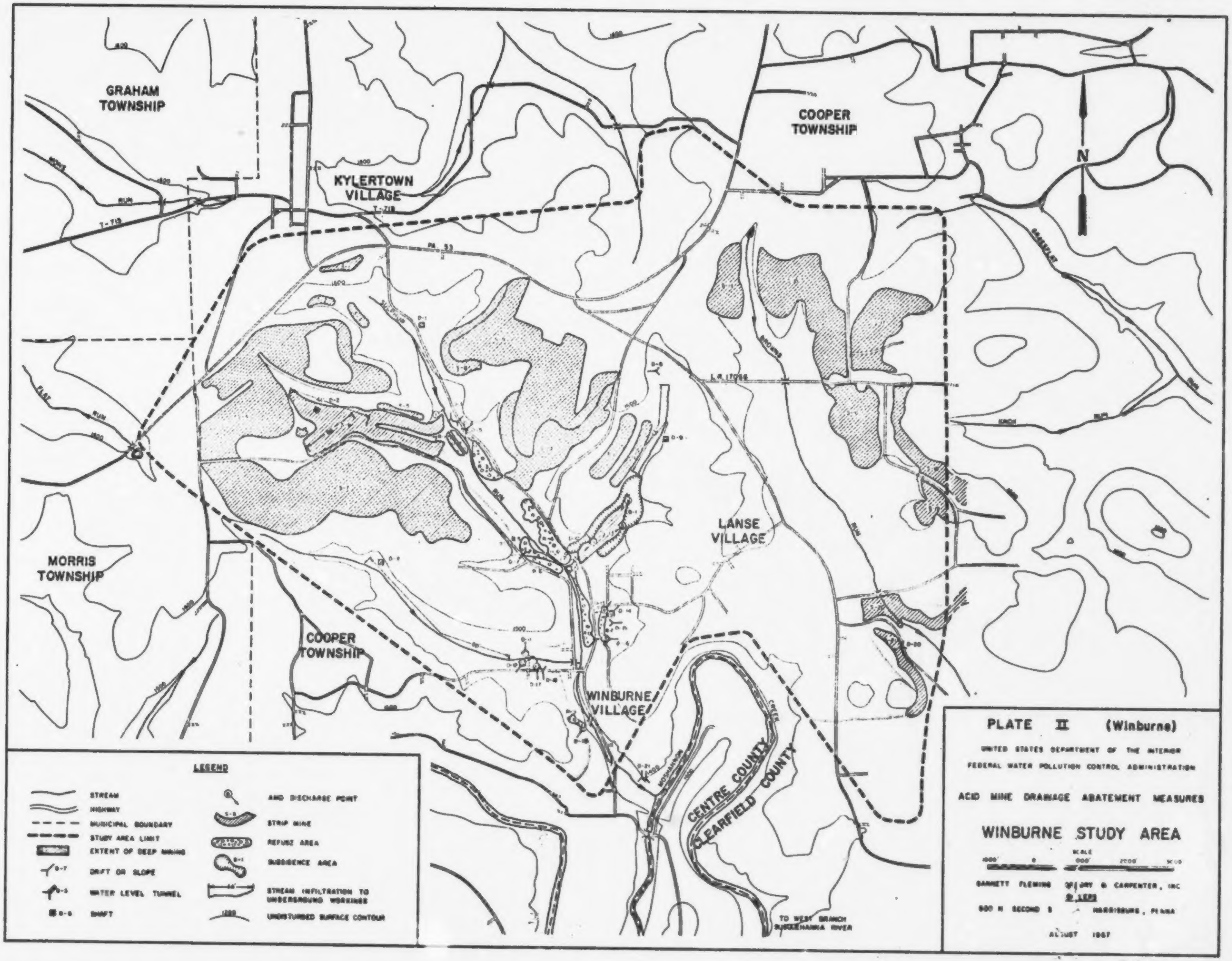
Pertinent Design and Cost Data For Recommended Abatement Plan

	Estimated AMD Reduction (1)				Average Annual Costs for Initial Thirty Years (1)			Average Annual Costs for Next Two Hundred Seventy Years (1)			Costs for Three Hundred Years (1)	
	Volume (mgd)	Iron (Tons/ Day)	Acid (Tons/ Day)	Project Cost	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Per Ton Of Acid Removed	Total
Preventive Measures												
Reconstruct stream channels in stream infiltration areas AA' through DD', 9,100 ft; restore strip mine S-6, 50 acres, 245,000 cu yds of fill (Refuse used to meet partial fill requirements)	0.20	0.47	1.60	$ 645,000	$ 37,200	$ 3,700	$ 70	$ 2,200	$ 800	$ 5.14	$11.60	$ 2,037,000
Restore major subsidence area, 20 acres; reconstruct stream channel in stream infiltration area EE', 2,000 ft; restore strip mines S-13, 20 and 21, 42 acres, 168,000 cu yds of fill (Refuse used to meet partial fill requirements)	0.34	0.26	1.10	307,000	17,800	2,800	51.40	500	600	2.74	7.60	915,000
Restore strip mines S-4, 5, 7, 8, 9 and 10, 461 acres, 1,470,000 cu yds of fill (Refuse used to meet partial fill requirements)	0.39	0.47	1.99	1,920,000	111,000	26,200	189	None	None	None	18.90	4,116,000
Subtotal	0.93	1.20	4.69	2,872,000	166,000	32,700	116	2,700	1,400	2.39	13.80	7,068,000

EXHIBIT I (Winburne Continued)
Page Two

	Estimated AMD Reduction (1)				Average Annual Costs for Initial Thirty Years (1)			Average Annual Costs for Next Two Hundred Seventy Years(1)			Costs for Three Hundred Years (1)	
	Volume (mgd)	Iron (Tons/ Day)	Acid (Tons/ Day)	Project Cost	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Fixed	Operation and Mainenance	Per Ton Of Acid Removed	Per Ton Of Acid Removed	Total
Treatment Measure												
Collection System 13,000 ft of open channel; 1 flow equalization basin; 1,900 ft of conveyance sewers from 24 to 30 in. diameter; 12,300 ft of stream relocation (FF' and GG')	--	--	--	1,452,000	83,900	50,100	--	10,200	50,900	--	--	20,517,000
Treatment Facilities	--	3.9(2)	20.0(3)	1,290,000	74,600	255,000	--	74,600	255,000	--	--	98,880,000
Subtotal	--	3.9	20.0	2,742,000	158,500	305,100	63.50	84,800	305,900	53.50	54.50	119,397,000
Total	0.93	5.1	24.69	5,614,000	324,500	337,800	73.50	87,500	307,300	43.80	46.75	126,465,000

(1) Calculated on basis of design average conditions
(2) To 7 mg/l
(3) To 0 mg/l as $CaCO_3$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KYLERTOWN VILLAGE
T-719
COOPER TOWNSHIP
N
PA. 53
L.R. 17098
FLAT RUN
MORRIS TOWNSHIP
COOPER TOWNSHIP
LANSE VILLAGE
WINBURNE VILLAGE
CENTRE COUNTY
CLEARFIELD COUNTY
TO WEST BRANCH SUSQUEHANNA RIVER
LEGEND
STREAM
HIGHWAY
MUNICIPAL BOUNDARY
STUDY AREA LIMIT
EXTENT OF DEEP MINING
DRIFT OR SLOPE
WATER LEVEL TUNNEL
SHAFT
AMD DISCHARGE POINT
STRIP MINE
REFUSE AREA
SUBSIDENCE AREA
STREAM INFILTRATION TO UNDERGROUND WORKINGS
UNDISTURBED SURFACE CONTOUR

PLATE II (Winburne)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

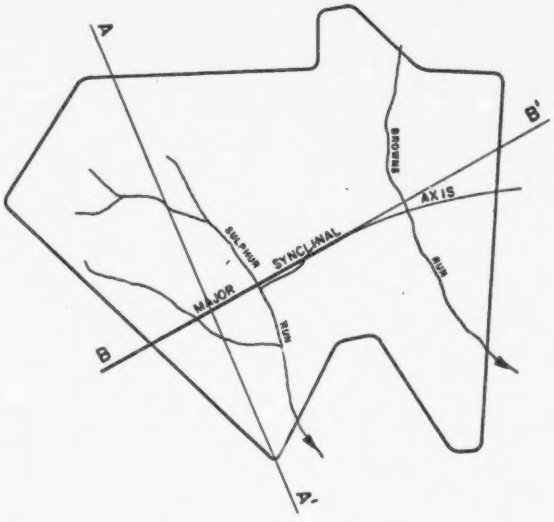
ACID MINE DRAINAGE ABATEMENT MEASURES

WINBURNE STUDY AREA

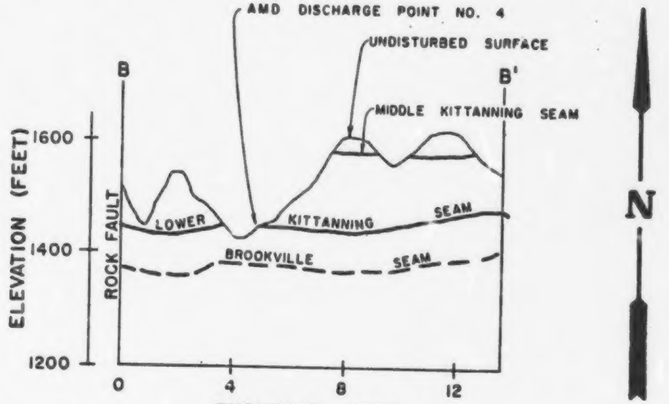
SCALE
1000' 0 1000' 2000' 3000'

GANNETT FLEMING CORDDRY & CARPENTER, INC
[illegible]
600 N SECOND S HARRISBURG, PENNA

AUGUST 1967


A
A'
B
B'
SULPHUR
RUN
BROWNS
RUN
MAJOR
SYNCLINAL
AXIS

STUDY AREA PLAN
SCALE 1" = 5000'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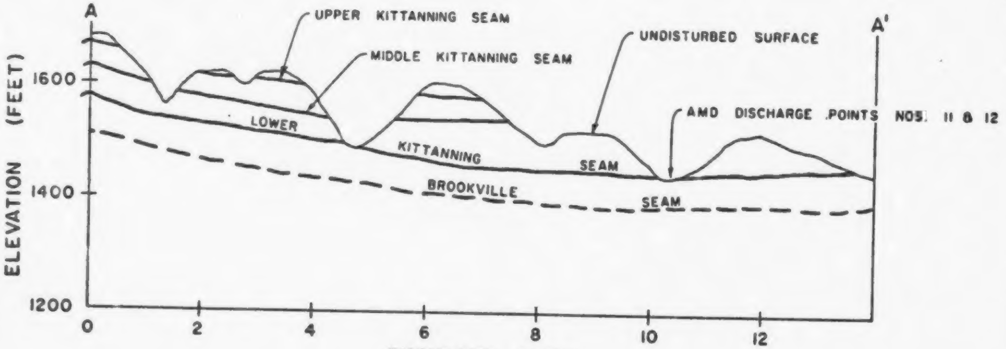
UNDISTURBED SURFACE
MIDDLE KITTANNING SEAM
B
B'
ELEVATION (FEET)
1600
1400
1200
ROCK FAULT
LOWER
KITTANNING
SEAM
BROOKVILLE
SEAM
0
4
8
12
N

THOUSAND FEET
SECTION B - B'

NOTE

1. DASHED LINES INDICATE AREAS WHERE COAL MEASURES HAVE NOT BEEN PROVEN TO BE CONSISTENTLY PRESENT.


A
A'
UPPER KITTANNING SEAM
MIDDLE KITTANNING SEAM
UNDISTURBED SURFACE
AMD DISCHARGE POINTS NOS. 11 & 12
ELEVATION (FEET)
1600
1400
1200
LOWER
KITTANNING
SEAM
BROOKVILLE
SEAM
0
2
4
6
8
10
12

THOUSAND FEET
SECTION A - A'

PLATE III (Winburne)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

WINBURNE COAL SEAMS

GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG PENNA.

AUGUST 1967

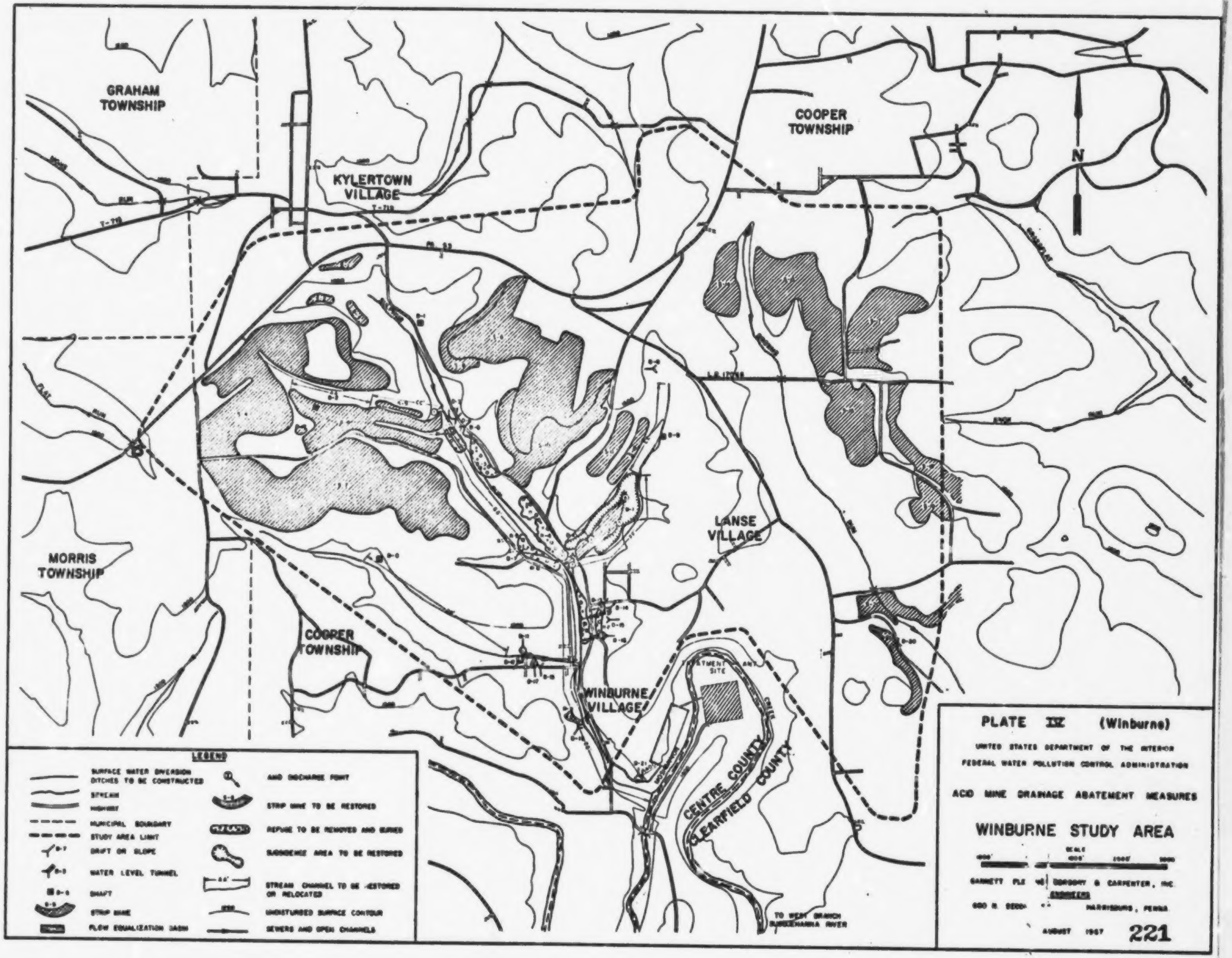

GRAHAM TOWNSHIP
KYLERTOWN VILLAGE
T-710
COOPER TOWNSHIP
N
MORRIS TOWNSHIP
COOPER TOWNSHIP
LANSE VILLAGE
WINBURNE VILLAGE
CENTRE COUNTY
CLEARFIELD COUNTY
TREATMENT SITE
TO WEST BRANCH SUSQUEHANNA RIVER
L.R. 17058
LEGEND
SURFACE WATER DIVERSION DITCHES TO BE CONSTRUCTED
STREAM
HIGHWAY
MUNICIPAL BOUNDARY
STUDY AREA LIMIT
DRIFT OR SLOPE
WATER LEVEL TUNNEL
SHAFT
STRIP MINE
FLOW EQUALIZATION BASIN
AND DISCHARGE POINT
STRIP MINE TO BE RESTORED
REFUSE TO BE REMOVED AND BURIED
SUBSIDENCE AREA TO BE RESTORED
STREAM CHANNEL TO BE RESTORED OR RELOCATED
UNDISTURBED SURFACE CONTOUR
SEWERS AND OPEN CHANNELS

PLATE IX (Winburne)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

WINBURNE STUDY AREA

SCALE

GANNETT FLE CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECO HARRISBURG, PENNA

AUGUST 1967

EXHIBIT H (Tremont)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Estimated AMD Volumes, Constituents And Characteristics
Remaining At Each Discharge Point After
Construction Of All Recommended Preventive Measures

	Design Average						Design Wet Weather						Design Maximum					
			Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3	
Discharge Point(1)	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day
1	.158	3.8-4.3	Tr.	.001	170	.112	.267	4.0-4.5	Tr.	.001	30	.036	6.941	4.5-6.3	Tr.	--	0	--
2	4.090	3.3-4.1	40	.648	200.	3.408	4.668	3.3-3.4	35	.660	170.	3.297	116.363	3.3-4.5	25	12.095	115.	55.589
3	.413	4.8-6.3	5.	.009	30.	.052	.515	5.9-6.3	5.	.011	40.	.086	13.064	5.5-6.3	5.	0.223	35.	1.907
4	.547	4.8-5.6	Tr.	.008	30.	.068	.773	5.3-5.6	Tr.	.006	25.	.081	19.596	5.5-6.3	Tr.	0.092	30.	2.452
5	.902	6.2-7.0	60.	.229	85.	.320	.922	3.3-3.7	35.	.134	110.	.422	22.982	4.0-6.0	10.	0.960	250.	23.992
6	.216	3.4-4.6	15.	.015	30.	.027	.461	5.0-5.6	25.	.048	75.	.142	11.851	5.0-6.0	10.	0.490	50.	2.470
7	.576	3.4-4.6	35.	.081	20.	.048	1.051	5.0-5.6	35.	.159	80.	.352	27.461	5.0-6.0	10.	1.145	50.	5.735

(1) Refer to Plate II (Tremont)

EXHIBIT I (Tremont)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Pertinent Design and Cost Data for Recommended Abatement Plan

	Estimated AMD Reduction (1)				Average Annual Costs for Initial Thirty Years (1)			Average Annual Costs for Next Two Hundred Seventy Years (1)			Costs For Three Hundred Years (1)	
	Volume (mgd)	Iron (Tons/Day)	Acid (Tons/Day)	Project Cost	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Per Ton Of Acid Removed	Total
Preventive Measures												
Divert Gebhard Run from deep mine entry D-22, and reconstruct stream channel BB'; 2,000 ft	0.13	Nil	0.02	$ 18,500	$ 1,050	$ None	$ 144	$ None	$ None	$ None	$14.40	$ 31,500
Reconstruct stream channels in all remaining stream infiltration areas; 11,700 ft	1.16	0.12	0.85	472,000	27,300	2,200	95.30	6,500	2,200	28.10	34.80	3,234,000
Construct surface water diversion ditches at strip mines S-1,5,5a, 6,9,23,26,27,29,30, 31, and 37; 31,000 ft	.17	0.10	0.26	38,100	2,200	7,500	102	None	7,500	79	81.40	2,316,000
Subtotal	1.46	0.22	1.13	528,600	30,550	9,700	97.50	6,500	9,700	39.30	45.10	5,581,500

EXHIBIT I (Tremont Continued)
Page Two

Treatment Measure	Estimated AMD Reduction (1)			Project Cost	Average Annual Costs for Initial Thirty Years (1)			Average Annual Costs for Next Two Hundred Seventy Years (1)			Costs For Three Hundred Years (1)	
	Volume (mgd)	Iron (Tons/ Day)	Acid (Tons/ Day)		Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Per Ton Of Acid Removed	Total
Collection System 700 ft of open channel; 3 flow equalization basins; 2 pumping sites; 22,700 ft of conveyance sewers from 6 to 18 in. diameter	--	--	--	$1,230,000	$ 71,200	$ 35,000	--	$ 21,400	$ 35,000	--	--	$18,414,000
Treatment Facilities	--	0.8 (2)	4.0 (3)	541,200	31,300	125,000	--	31,300	125,000	--	--	46,890,000
Subtotal	--	0.8	4.0	1,771,200	102,500	160,000	180	52,700	160,000	146	149	65,304,000
Total	1.46	1.02	5.13	2,299,800	133,050	169,700	162	59,200	169,700	122	126	70,885,500

(1) Calculated on basis of design average conditions
(2) To 7 mg/l
(3) To 0 mg/l as $CaCO_3$

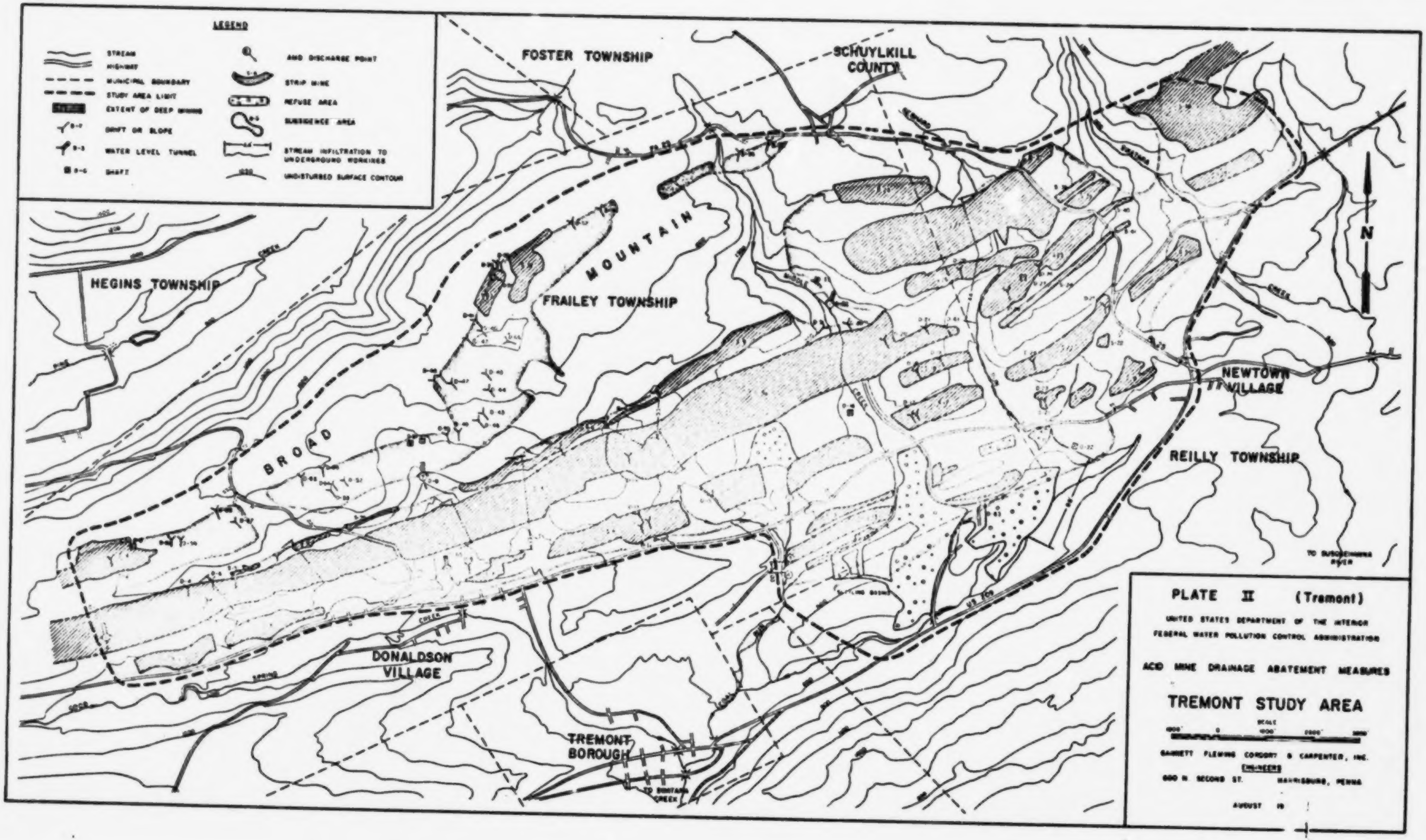

LEGEND
STREAM
HIGHWAY
MUNICIPAL BOUNDARY
STUDY AREA LIMIT
EXTENT OF DEEP MINING
DRIFT OR SLOPE
WATER LEVEL TUNNEL
SHAFT
AND DISCHARGE POINT
STRIP MINE
REFUSE AREA
SUBSIDENCE AREA
STREAM INFILTRATION TO UNDERGROUND WORKINGS
UNDISTURBED SURFACE CONTOUR
FOSTER TOWNSHIP
SCHUYLKILL COUNTY
HEGINS TOWNSHIP
BROAD MOUNTAIN
FRAILEY TOWNSHIP
NEWTOWN VILLAGE
REILLY TOWNSHIP
DONALDSON VILLAGE
TREMONT BOROUGH
N
TO SUSQUEHANNA RIVER
CREEK
SCALE

PLATE II (Tremont)

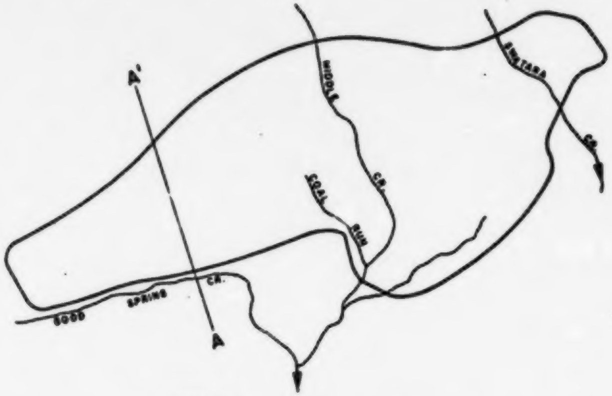
UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

TREMONT STUDY AREA

GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.

AUGUST 19

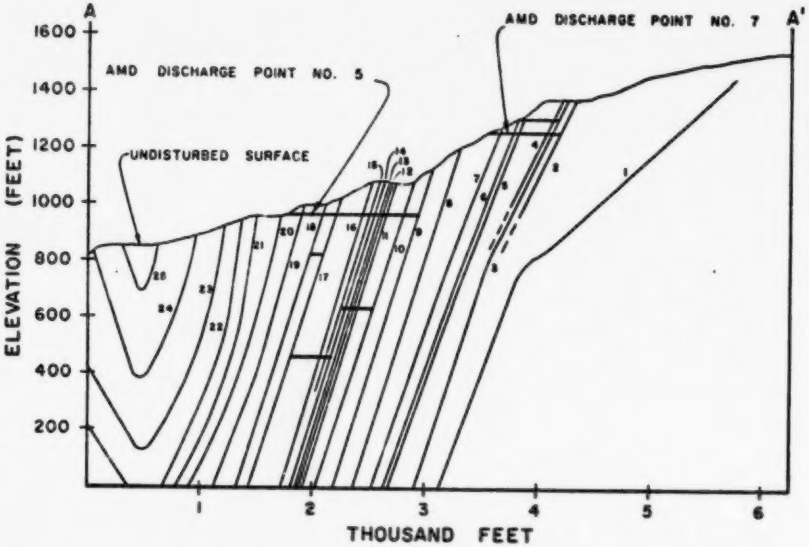

A'
A
MIDDLE CR.
SWATARA CR.
COAL RUN
GOOD SPRING CR.

STUDY AREA PLAN
SCALE 1" = 5000'

COAL VEINS

1	LYKENS VALLEY NO. 6 VEIN
2	UNNAMED
3	LYKENS VALLEY NO. 5 VEIN
4	LYKENS VALLEY NO. 4 VEIN
5	LYKENS VALLEY NO. 3 VEIN
6	LYKENS VALLEY NO. 2 VEIN
7	LYKENS VALLEY NO. 1.5 VEIN
8	LYKENS VALLEY NO. 1 VEIN
9	LITTLE BUCK MOUNTAIN VEIN
10	BUCK MOUNTAIN VEIN
11	SEVEN FOOT VEIN
12	SKIDMORE VEIN
13	BOTTOM SPLIT OF MAMMOTH VEIN
14	MIDDLE SPLIT OF MAMMOTH VEIN
15	TOP SPLIT OF MAMMOTH VEIN
16	FOUR FOOT VEIN
17	HOLMES VEIN
18	PRIMROSE VEIN
19	ORCHARD VEIN
20	LITTLE ORCHARD VEIN
21	DIAMOND VEIN
22	LITTLE DIAMOND VEIN
23	TRACY VEIN
24	LITTLE TRACY VEIN
25	PEACH MOUNTAIN VEIN

N


A
A'
AMD DISCHARGE POINT NO. 7
AMD DISCHARGE POINT NO. 5
UNDISTURBED SURFACE
ELEVATION (FEET)
1600
1400
1200
1000
800
600
400
200
1
2
3
4
5
6
THOUSAND FEET
1
2
3
4
5
6
7
8
9
10
11
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22
23
24
25

SECTION A - A'

NOTES

1. COAL VEINS ALONG A NORTHEAST-SOUTHWEST SECTION CANNOT BE ACCURATELY PRESENTED BECAUSE OF A LACK OF PERTINENT INFORMATION. HOWEVER, SUCH A CROSS SECTION WOULD GENERALLY SHOW THESE COAL VEINS AS A SERIES OF HORIZONTAL LINES INTERSPERSED BY LOCAL FAULTS AND INTERRUPTIONS. THE NORTHEASTERN LIMIT OF THE STUDY AREA IS DEFINED BY A BARRIER PILLAR AND ROCK FAULT; THE SOUTHWESTERN LIMIT BY A BARRIER PILLAR.
2. WATER LEVEL TUNNELS TO THE SOUTH AND SOUTHEAST OF THE STUDY AREA PREVENT FLOW OF GROUND WATER INTO THAT SAME AREA.
3. THE MAJOR SYNCLINAL AXIS CANNOT BE SHOWN BECAUSE OF A LACK OF PERTINENT INFORMATION.
4. DASHED LINES INDICATE AREAS WHERE COAL MEASURES HAVE NOT BEEN PROVEN TO BE CONSISTENTLY PRESENT.

PLATE III (Tremont)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

TREMONT COAL VEINS

GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.

AUGUST 1967

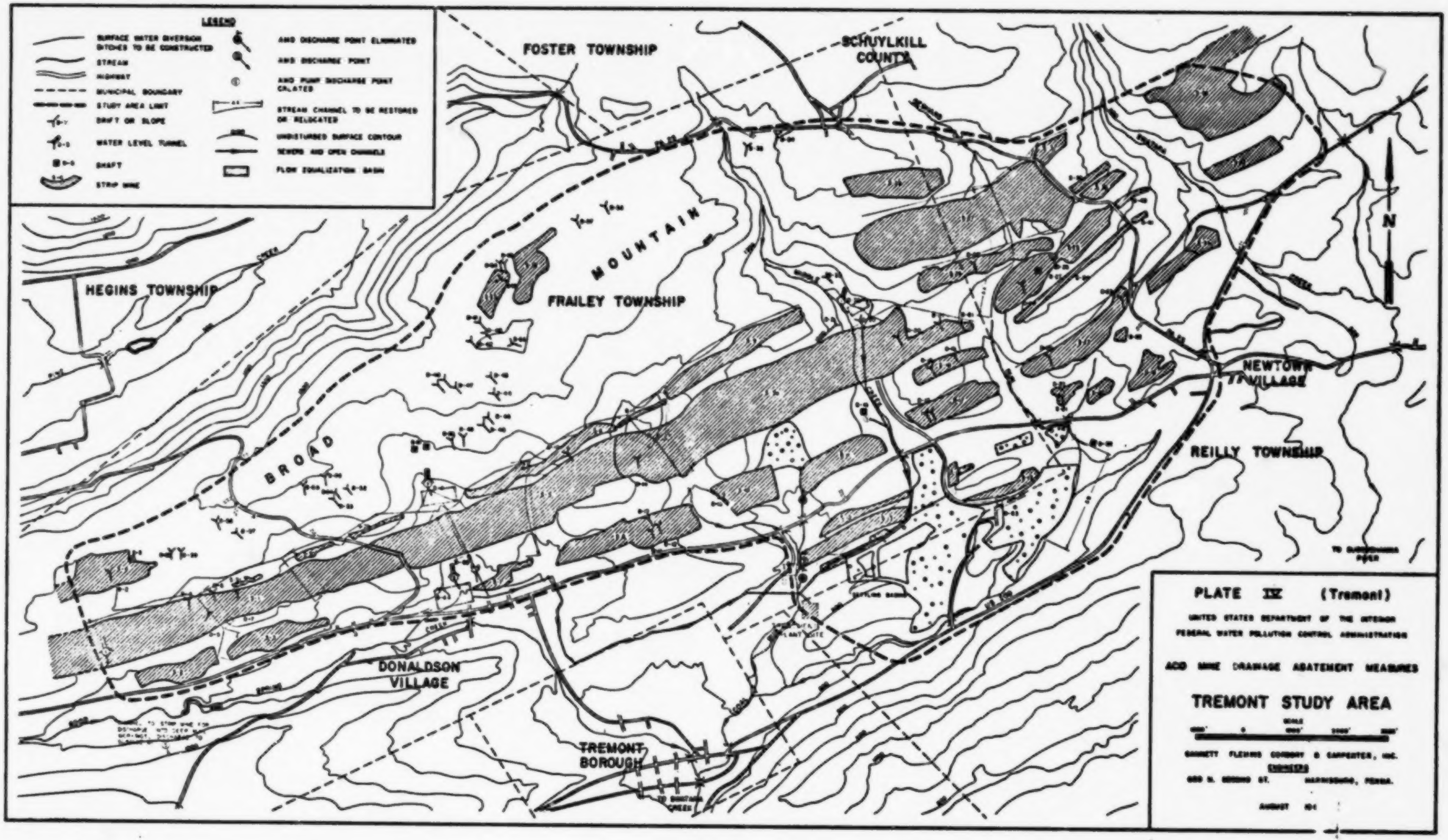

LEGEND
SURFACE WATER DIVERSION DITCHES TO BE CONSTRUCTED
STREAM
HIGHWAY
MUNICIPAL BOUNDARY
STUDY AREA LIMIT
DRIFT OR SLOPE
WATER LEVEL TUNNEL
SHAFT
STRIP MINE
AMD DISCHARGE POINT ELIMINATED
AMD DISCHARGE POINT
AMD PUMP DISCHARGE POINT LOCATED
STREAM CHANNEL TO BE RESTORED OR RELOCATED
UNDISTURBED SURFACE CONTOUR
SEWERS AND OPEN CHANNELS
FLOW EQUALIZATION BASIN
N
FOSTER TOWNSHIP
SCHUYLKILL COUNTY
HEGINS TOWNSHIP
MOUNTAIN
FRAILEY TOWNSHIP
BROAD
NEWTOWN VILLAGE
REILLY TOWNSHIP
DONALDSON VILLAGE
TREMONT BOROUGH
TO SUSQUEHANNA RIVER
SCALE

PLATE IV (Tremont)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

TREMONT STUDY AREA

GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.

AUGUST [illegible]

EXHIBIT A (Coaldale)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Deep Mine Entries

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-1	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed	21
D-2	Drift	Lower Kittanning	X	--	Open, underground workings exposed	21
D-3	Drift	Clarion	X	--	Open, underground workings exposed, AMD discharge point 21 (1)	21
D-4	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	19, 20
D-5	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	19, 20
D-6	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	21
D-7	Shaft	Lower Kittanning	--	X	Filled, no underground workings exposed	17
D-8	Drift	Lower Kittanning	--	X	Open, underground workings exposed	17

EXHIBIT A (Coaldale Continued)
Page Two

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-9	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed, AMD discharge point 19 (1)	19
D-10	Shaft	Upper Freeport	--	X	Filled, no underground workings exposed	19
D-11	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	17
D-12	Drift	Upper Freeport	--	X	Open, underground workings exposed	19
D-13	Drift	Lower Kittanning	--	X	Three entries, all caved, no underground workings exposed	17
D-14	Drift	Upper Freeport	--	X	Three entries, all caved, no underground workings exposed	17
D-15	Drift	Middle Kittanning	--	X	Two entries, both partially caved, underground workings exposed, AMD discharge point 22 (1)	22
D-16	Drift	Middle Kittanning	--	X	Caved, no underground workings exposed	22
D-17	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	17
D-18	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	17

EXHIBIT A (Coaldale Continued)
Page Three

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-19	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	17
D-20	Drift	Middle Kittanning	--	X	Caved, no underground workings exposed, stripped by S-6 (1)	22
D-21	Drift	Middle Kittanning	--	X	Open, underground workings exposed, driven into highwall of S-7 (1)	22
D-22	Drift	Pittsburgh	--	X	Two entries, partially caved, underground workings exposed, partially flooded, driven into highwall of S-11 (1)	17
D-23	Slope	Upper Freeport	--	X	Caved, no underground workings exposed	17
D-24	Water Level Tunnel	Upper Freeport	--	X	Partially caved, underground workings exposed, AMD discharge point 16 (1)	16
D-25	Drift	Upper Freeport	--	X	Sealed, no underground workings exposed, AMD discharge point 15 (1)	15
D-26	Shaft	Lower Kittanning	--	X	Filled, no underground workings exposed	15, 16
D-27	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	15, 16

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-28	Drift	Upper Freeport	--	X	Open, underground workings exposed	15, 16
D-29	Drift	Upper Freeport	--	X	Open, underground workings exposed	15, 16
D-30	Shaft	Upper Freeport	--	X	Open, underground workings exposed	15, 16
D-31	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	15, 16
D-32	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	15, 16
D-33	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	15, 16
D-34	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	15, 16
D-35	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	15, 16
D-36	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	24
D-37	Shaft	Lower Kittanning	--	X	Filled, no underground workings exposed	24
D-38	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	24

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-39	Shaft	Middle Kittanning	--	X	Partially caved, underground workings exposed	22
D-40	Drift	Pittsburgh	--	X	Partially caved, underground workings exposed, driven into highwall of S-28 (1)	15, 16
D-41	Drift	Speer	--	X	Partially caved, underground workings exposed, driven into highwall of S-25 (1)	15, 16
D-42	Drift	Speer	--	X	Partially caved, underground workings exposed, driven into highwall of S-25 (1)	15, 16
D-43	Drift	Speer	X	--	Three entries, all open, underground workings exposed, driven into highwall of S-23 (1)	15, 16
D-44	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	24
D-45	Drift	Upper Freeport	--	X	Open, underground workings exposed	24
D-46	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	24
D-47	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	24
D-48	Drift	Upper Freeport	--	X	Open, underground workings exposed	24

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine Active	Current Status Of Mine Inactive	Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
D-49	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	24
D-50	Slope	Clarion	--	X	Caved, no underground workings exposed	14
D-51	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	14
D-52	Drift	Upper Freeport	--	X	Two entries, both caved, no underground workings exposed	14
D-53	Drift	Upper Freeport	--	X	Two entries, both caved, no underground workings exposed	14
D-54	Drift	Lower Kittanning	--	X	Closed, no underground workings exposed	14
D-55	Drift	Lower Kittanning	--	X	Two entries, both caved, no underground workings exposed	14
D-56	Drift	Clarion	--	X	Caved, no underground workings exposed, AMD discharge point 14 (1)	14
D-57	Drift	Upper Freeport	--	X	Four entries, all open, underground workings exposed	24
D-58	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	12
D-59	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	12

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-60	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed, AMD discharge point 13 (1)	13
D-61	Drift	Clarion	--	X	Sealed, no underground workings exposed, AMD discharge point 12 (1)	12
D-62	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	4
D-63	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	12
D-64	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	12
D-65	Drift	Upper Freeport	X	--	Open, underground workings exposed	13
D-66	Drift	Upper Freeport	X	--	Open, underground workings exposed	13
D-67	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	13
D-68	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	12
D-69	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed, AMD discharge point 7 (1)	7, 13

EXHIBIT A (Coaldale Continued)
Page Eight

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-70	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	7, 13
D-71	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed	8
D-72	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed, stripped by S-14 (1), AMD discharge point 8 (1)	8
D-73	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed, stripped by S-14 (1)	8
D-74	Shaft	Clarion	--	X	Open, underground workings exposed	12
D-75	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	12, 13
D-76	Slope	Lower Kittanning	--	X	Caved, no underground workings exposed, AMD discharge point 9 (1)	9
D-77	Drift	Upper Freeport	--	X	Three entries, all caved, no underground workings exposed, stripped by S-16 (1), AMD discharge points 10 & 11 (1)	10, 11
D-78	Drift	Upper Freeport	--	X	Caved, no underground workings exposed, stripped by S-19 (1)	10, 11
D-79	Drift	Upper Freeport	--	X	Caved, no underground workings exposed, Stripped by S-19 (1)	10, 11

EXHIBIT A (Coaldale Continued)
Page Nine

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-80	Drift	Upper Freeport	--	X	Open, underground workings exposed	10, 11
D-81	Drift	Upper Freeport	X	--	Open, underground workings exposed	10, 11
D-82	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	15, 16
D-83	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	15, 16
D-84	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	15, 16
D-85	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed	15, 16
D-86	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed	15, 16
D-87	Drift	Upper Freeport	--	X	Four entries, all caved, no underground workings exposed	15, 16
D-88	Drift	Lower Kittatinning	--	X	Sealed, no underground workings exposed, AMD discharge point 6 (1)	6
D-89	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	15, 16

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-90	Shaft	Clarion	--	X	Filled, no underground workings exposed, AMD discharge point 4 (1)	4
D-91	Drift	Clarion	--	X	Caved, no underground workings exposed, AMD discharge point 5 (1)	5
D-92	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	2
D-93	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	2
D-94	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed	15, 16
D-95	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed	15, 16
D-96	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	15, 16
D-97	Drift	Upper Freeport	X	--	Open, underground workings exposed	15, 16
D-98	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	15, 16
D-99	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	15, 16

EXHIBIT A (Coaldale Continued)
Page Eleven

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-100	Drift	Speer	--	X	Sealed, no underground workings exposed, AMD discharge point 18 (1)	18
D-101	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	2
D-102	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	2
D-103	Drift	Clarion	--	X	Caved, no underground workings exposed	2
D-104	Drift	Clarion	--	X	Partially caved, underground workings exposed, formerly sealed, AMD discharge point 2 (1)	2
D-105	Drift	Upper Freeport	--	X	Open, underground workings exposed	2
D-106	Drift	Upper Freeport	--	X	Partially caved, underground workings exposed	2
D-107	Drift	Upper Freeport	--	X	Sealed, no underground workings exposed, AMD discharge point 1 (1)	1
D-108	Drift	Speer	X	--	Open, underground workings exposed	--
D-109	Drift	Speer	X	--	Open, underground workings exposed	--

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-110	Drift	Clarion	--	X	Three entries, all caved, no underground workings exposed, AMD discharge point 3 (1)	3, 23
D-111	Drift	Pittsburgh	--	X	Partially caved, underground workings exposed, partially flooded, driven into highwall of S-4	16, 19
D-112	Drift	Pittsburgh	--	X	Caved, no underground workings exposed	16, 19
D-113	Drift	Pittsburgh	--	X	Caved, no underground workings exposed	16, 19
D-114	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	8
D-115	Drift	Upper Freeport	--	X	Caved, no underground workings exposed	8
D-116	Drift	Lower Kittanning	--	X	Three entries, all caved, no underground workings exposed	6
D-117	Borehole	Clarion and Lower Kittanning	--	X	Formerly capped, no underground workings exposed, artesian flow, AMD discharge point 24 (1)	24

(1) Refer to Plate II (Coaldale)

EXHIBIT D (Coaldale)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Strip Mines

Strip Mine (1)	Coal Seam Stripped	Current Status Of Mine		Affected Acreage	Strip Pit			Type Of Interconnection With Deep Mine Workings		MD Discharge Point With Which Strip Mine Communicates (1)
		Active	Inactive		Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	
S-1	Speer	--	X	2.1	400	400	Sloped to highwall	--	X	16, 19
S-2	Speer	--	X	5.9	1,000	1,000	Sloped to highwall	--	X	16, 19
S-3	Pittsburgh	--	X	14.3	1,500	1,500	Sloped to highwall	--	X	16, 19
S-4	Pittsburgh	--	X	33.4	3,300	3,300	Sloped to highwall	X	--	16, 19
S-5	Speer	--	X	4.2	750	750	Sloped to highwall	--	X	16, 19
S-6	Middle Kittanning	--	X	1.7	300	300	None	X	--	16, 19
S-7	Middle Kittanning	--	X	5.6	1,000	0	None	X	--	17, 22
S-8	Middle Kittanning	--	X	1.4	400	0	None	--	X	17, 22
S-9	Middle Kittanning	--	X	2.8	600	0	None	--	X	17, 22
S-10	Pittsburgh	--	X	5.2	500	500	Pasture	--	X	17, 22
S-11	Pittsburgh	--	X	2.4	500	0	None	X	--	17
S-12	Pittsburgh	--	X	4.5	0	0	None	--	X	17

EXHIBIT D (Coaldale Continued)
Page Two

Strip Mine (1)	Coal Seam Stripped	Current Status Of Mine		Affected Acreage	Strip Pit			Type Of Interconnection With Deep Mine Workings		MD Discharge Point With Which Strip Mine Communicates (1)
		Active	Inactive		Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	
S-13	Upper Freeport	--	X	6.3	1,800	450 1,350	Sloped to highwall Pasture	--	X	8, 9
S-14	Lower Kittanning	--	X	7.0	2,000	2,000	Sloped to highwall	X	--	6, 9
S-15	Upper Freeport	--	X	23.1	3,400	1,700 1,700	None Sloped to highwall	X	--	10, 11
S-16	Lower Kittanning and Upper Freeport	--	X	20.3	1,800	1,800	Pasture to near contour	X	--	10, 11
S-17	Speer	--	X	172.	8,000	0	None	--	X	10, 11
S-18	Upper Freeport	--	X	5.6	1,200	0	None	--	--	--
S-19	Upper Freeport	--	X	18.3	3,200	3,200	Pasture to near contour	X	--	10, 11
S-20	Speer	--	X	6.6	1,400	0	None	X	--	18
S-21	Speer	--	X	12.5	1,500	1,500	Sloped to highwall	X	--	2
S-22	Speer	--	X	32.7	3,600	3,600	Sloped to highwall	X	--	15, 16
S-23	Upper Freeport	--	X	3.5	1,100	0	None	X	--	15, 16

Strip Mine (1)	Coal Seam Stripped	Current Status Of Mine		Affected Acreage	Strip Pit			Type Of Interconnection With Deep Mine Workings		MD Discharge Point With Which Strip Mine Communicates (1)
		Active	Inactive		Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	
S-24	Speer	--	X	10.1	700	700	Sloped to highwall	X	--	15, 16
S-25	Upper Freeport	--	X	3.5	500	500	Sloped to highwall	--	X	15, 16
S-26	Pittsburgh	X	--	5.9	600	Active	Partially back-filled to date	--	X	15, 16
S-27	Pittsburgh	--	X	3.1	600	0	None	--	X	15, 16
S-28	Pittsburgh	X	--	2.5	500	Active	None to date	--	X	15, 16

(1) Refer to Plate II (Coaldale)

EXHIBIT G (Coaldale)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Design MD Volumes, Constituents And Characteristics At Each Discharge Point

	Design Average						Design Wet Weather						Design Maximum					
			Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3				Total Iron		Acid as CaCO3	
Dis-charge Point(1)	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day
1	.007	2.6-3.2	25	.001	335	.010	.010	3.2-3.6	Tr.	--	75	.003	.158	3.6-4.8	Tr.	--	20	.013
2	.081	3.0-3.3	30	.010	235	.076	.124	3.2-3.4	15	.008	215	.112	1.787	3.4-4.4	Tr.	008	80	.600
3	.123	3.0-3.5	15	.006	120	.060	.166	3.1-3.6	10	.006	75	.052	2.405	3.6-4.8	Tr.	010	10	.101
4	.088	3.0-3.4	Tr.	.001	110	.040	.249	3.5-3.7	Tr.	.001	90	.093	3.571	3.6-4.8	Tr.	--	30	.444
5	--	--	--	--	--	--	.036	2.9-3.1	10	.002	275	.042	.547	3.4-4.2	10	.018	120	.274
6	.052	2.6-2.8	20	.004	260	.056	.157	2.9-3.1	20	.012	225	.147	2.246	3.4-4.2	10	.114	110	1.038
7	.032	2.6-3.0	140	.018	480	.062	.084	2.8-3.4	70	.002	250	.087	1.238	3.6-4.8	15	.068	35	.172
8	.140	2.6-2.8	35	.022	360	.208	.249	2.7-2.9	45	.049	380	.394	3.571	3.0-3.9	70	1.038	430	6.360
9	.014	2.8-3.2	15	.001	220	.012	.033	3.3-3.4	5	.001	115	.016	.461	3.6-4.6	Tr.	.004	50	.097
10	.259	2.8-3.0	15	.018	300	.326	.464	3.0-3.1	10	.022	205	.394	6.754	3.4-4.2	5	.142	95	2.688
11	.328	2.8-3.0	20	.024	295	.405	.598	2.9-3.1	15	.035	215	.530	8.611	3.4-4.2	5	.252	105	3.790
12	.022	3.0-3.3	15	.001	215	.018	.033	3.3-3.5	15	.002	155	.022	.462	3.6-4.8	5	.006	40	.078
13	.154	3.5-4.3	5	.005	70	.046	.282	4.2-4.5	5	.006	50	.058	4.118	4.2-5.0	5	.051	30	.510
14	.171	2.9-3.2	50	.036	455	.328	.249	3.0-3.3	15	.016	180	.188	3.571	3.6-4.8	Tr.	.030	15	.222
15	.171	3.0-3.5	45	.032	225	.162	.265	3.0-3.3	20	.024	210	.231	3.888	3.4-4.2	10	.130	110	1.788
16	.276	3.3-3.8	30	.035	145	.167	.331	3.3-3.8	25	.034	130	.179	4.810	3.6-4.6	10	.200	60	1.200
17	.157	3.8-6.0	80	.053	175	.116	.157	3.8-5.6	60	.039	150	.098	2.246	3.8-6.0	5	.047	50	.468
18	.029	3.0-3.3	5	.001	150	.018	.050	3.1-3.3	5	.001	115	.025	.698	3.6-4.8	Tr.	.006	45	.132
19	.482	3.0-3.1	10	.016	335	.672	.622	3.0-3.1	5	.015	320	.828	9.000	3.2-3.9	5	.113	275	10.382
20	.017	2.9-3.2	140	.010	710	.051	.033	2.8-3.2	120	.016	470	.065	.461	3.4-3.9	80	.155	260	.504
21	.007	2.7-3.0	240	.007	1490	.043	.017	2.6-3.0	315	.022	1740	.120	.230	3.0-3.6	450	.437	2000	1.945
22	.017	4.0-4.6	Tr.	--	65	.005	.033	4.4-4.6	Tr.	--	70	.010	.461	4.4-5.6	Tr.	--	80	.155
23	.035	2.7-3.2	5	.001	140	.021	.053	3.2-3.3	Tr.	.001	120	.026	.778	3.6-4.6	Tr.	--	50	.162
24	.837	2.5-2.7	25	.083	300	1.046	1.066	2.6-2.7	15	.067	240	1.070	15.530	3.0-4.0	5	.454	120	7.777

(1) Refer to Plate II (Coaldale)

EXHIBIT H (Coaldale)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Estimated AMD Volumes, Constituents And Characteristics Remaining At Each Discharge Point After Construction Of All Recommended Preventive Measures

	Design Average						Design Wet Weather						Design Maximum					
			Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3				Total Iron		Acid-as CaCO3	
Dis-charge Point (1)	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day	Total Daily Volume (MG)	pH Range	mg/l	Tons/ Day	mg/l	Tons/ Day
1	0.007	2.6-3.2	25	0.001	335	0.010	0.010	3.2-3.6	Tr.	--	75	0.003	0.158	3.6-4.8	Tr.	--	20	0.013
2	0.081	3.0-3.3	30	0.010	235	0.076	0.124	3.2-3.4	15	0.008	215	0.112	1.787	3.4-4.4	Tr.	0.008	80	0.600
3	0.000	--	--	--	--	--	0.000	--	--	--	--	--	0.000	--	--	--	--	--
4	0.088	3.0-3.4	Tr.	0.001	110	0.040	0.249	3.5-3.7	Tr.	0.001	90	0.093	3.571	3.6-4.8	Tr.	--	30	0.444
5	--	--	--	--	--	--	0.036	2.9-3.1	10	0.002	275	0.042	0.547	3.4-4.2	10	0.018	120	0.274
6	0.052	2.6-2.8	20	0.004	260	0.056	0.157	2.9-3.1	20	0.012	225	0.147	2.246	3.4-4.2	10	0.114	110	1.038
7	0.032	2.6-3.0	140	0.018	480	0.062	0.084	2.8-3.4	70	0.002	250	0.087	1.238	3.6-4.8	15	0.068	35	0.172
8	0.140	2.6-2.8	35	0.022	360	0.208	0.249	2.7-2.9	45	0.049	380	0.394	3.571	3.0-3.9	70	1.038	430	6.360
9	0.014	2.8-3.2	15	0.001	220	0.012	0.033	3.3-3.4	5	0.001	115	0.016	0.461	3.6-4.6	Tr.	0.004	50	0.097
10	0.233	2.8-3.0	15	0.016	300	0.293	0.408	3.0-3.1	10	0.019	205	0.346	5.523	3.4-4.2	5	0.116	95	2.197
11	0.296	2.8-3.0	20	0.022	295	0.365	0.527	2.9-3.1	15	0.031	215	0.467	7.049	3.4-4.2	5	0.206	105	3.102
12	0.022	3.0-3.3	15	0.001	215	0.018	0.033	3.3-3.5	15	0.002	155	0.022	0.462	3.6-4.8	5	0.006	40	0.078
13	0.154	3.5-4.3	5	0.005	70	0.046	0.282	4.2-4.5	5	0.006	50	0.058	4.118	4.2-5.0	5	0.051	30	0.510
14	0.119	2.9-3.2	50	0.025	455	0.228	0.161	3.0-3.3	15	0.010	180	0.122	1.569	3.6-4.8	Tr.	0.013	15	0.097
15	0.083	3.0-3.5	45	0.016	225	0.079	0.135	3.0-3.3	20	0.012	210	0.118	2.333	3.4-4.2	10	0.078	110	1.073
16	0.132	3.3-3.8	30	0.017	145	0.079	0.170	3.3-3.8	25	0.017	130	0.092	2.909	3.6-4.6	10	0.121	60	0.725
17	0.075	3.8-6.0	80	0.025	175	0.055	0.079	3.8-5.6	60	.039	150	.098	2.246	3.8-6.0	5	.047	50	.468
18	0.000	--	--	--	--	--	0.000	--	--	--	--	--	0.000	--	--	--	--	--
19	0.322	3.0-3.1	10	0.011	335	0.449	0.405	3.0-3.1	5	.015	320	.828	9.000	3.2-3.9	5	.113	275	10.382
20	0.017	2.9-3.2	140	0.010	710	0.051	0.033	2.8-3.2	120	.016	470	.065	.461	3.4-3.9	80	.155	260	.504
21	0.007	2.7-3.0	240	0.007	1,490	0.043	0.017	2.6-3.0	315	.022	1740	.120	.230	3.0-3.6	450	.437	2000	1.945
22	0.017	4.0-4.6	Tr.	--	65	0.005	0.033	4.4-4.6	Tr.	--	70	.010	.461	4.4-5.6	Tr.	--	80	.155
23	0.035	2.7-3.2	5	0.001	140	0.021	0.053	3.2-3.3	Tr.	.001	120	.026	.778	3.6-4.6	Tr.	--	50	.162
24	0.837	2.5-2.7	25	0.083	300	1.046	1.066	2.6-2.7	15	.067	240	1.070	15.530	3.0-4.0	5	.454	120	7.777

(1) Refer to Plate II (Coaldale)

EXHIBIT I (Coaldale)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Pertinent Design and Cost Data for Recommended Abatement Plan

	Estimated AMD Reduction (1)				Average Annual Costs for Initial Thirty Years (1)			Average Annual Costs for Next Two Hundred Seventy Years (1)			Costs for Three Hundred Years (1)	
	Volume (mgd)	Iron (Tons/ Day)	Acid (Tons/ Day)	Project Cost	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Per Ton Of Acid Removed	Total
Preventive Measures												
Reconstruct stream channels in all stream infiltration areas, and in vicinity of AMD discharges 17 and 23 (DD' and EE'); 7,000 ft	0.52	0.08	0.55	$ 81,500	$ 4,700	$ 700	$ 26.90	$ 2,100	$ 700	$ 13.95	$15.25	$ 918,000
Restore strip mine S-20, 6.6 acres, 120,000 cu yds of fill; construct watertight seal in deep mine entry D-100 (Refuse used to meet fill requirement)	0.03	Nil	0.02	105,100	6,100	400	890	None	None	None	89.20	195,000
Construct watertight seal in deep mine entry D-110	0.12	Nil	0.06	5,400	300	500	36.50	None	500	22.80	24.20	159,000
Restore strip mine S-15, 23 acres, 238,000 cu yds of fill (Refuse used to meet partial fill requirement)	0.06	Nil	0.07	219,500	12,700	1,100	540	None	None	None	54	414,000
Subtotal	0.73	0.09	0.70	411,500	23,800	2,700	104	2,100	1,200	12.90	22	1,686,000

EXHIBIT I (Coaldale Continued)
Page Two

	Estimated AMD Reduction (1)				Average Annual Costs for Initial Thirty Years (1)			Average Annual Costs for Next Two Hundred Seventy Years (1)			Costs for Three Hundred Years (1)	
Treatment Measure	Volume (mgd)	Iron (Tons/ Day)	Acid (Tons/ Day)	Project Cost	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Fixed	Operation and Maintenance	Per Ton Of Acid Removed	Per Ton Of Acid Removed	Total
Collection System 1,700 ft of open channel; 12 flow equalization basins; 3 pumping sites; 43,400 ft of conveyance sewers from 6 to 24 in. diameter	--	--	--	1,782,000	103,000	37,200	--	40,200	37,200	--	--	25,104,000
Treatment Facilities	--	0.3(2)	3.2(3)	393,000	22,700	101,300	--	22,700	101,000	--	--	37,119,000
Subtotal	--	0.3	3.2	2,175,000	125,700	138,500	226	62,900	138,200	172	178	62,223,000
Total	0.73	0.39	3.9	2,586,500	149,500	141,200	204	65,000	139,400	144	150	63,909,000

(1) Calculated on basis of design average conditions
(2) To 7 mg/l
(3) To 0 mg/l as $CaCO_3$

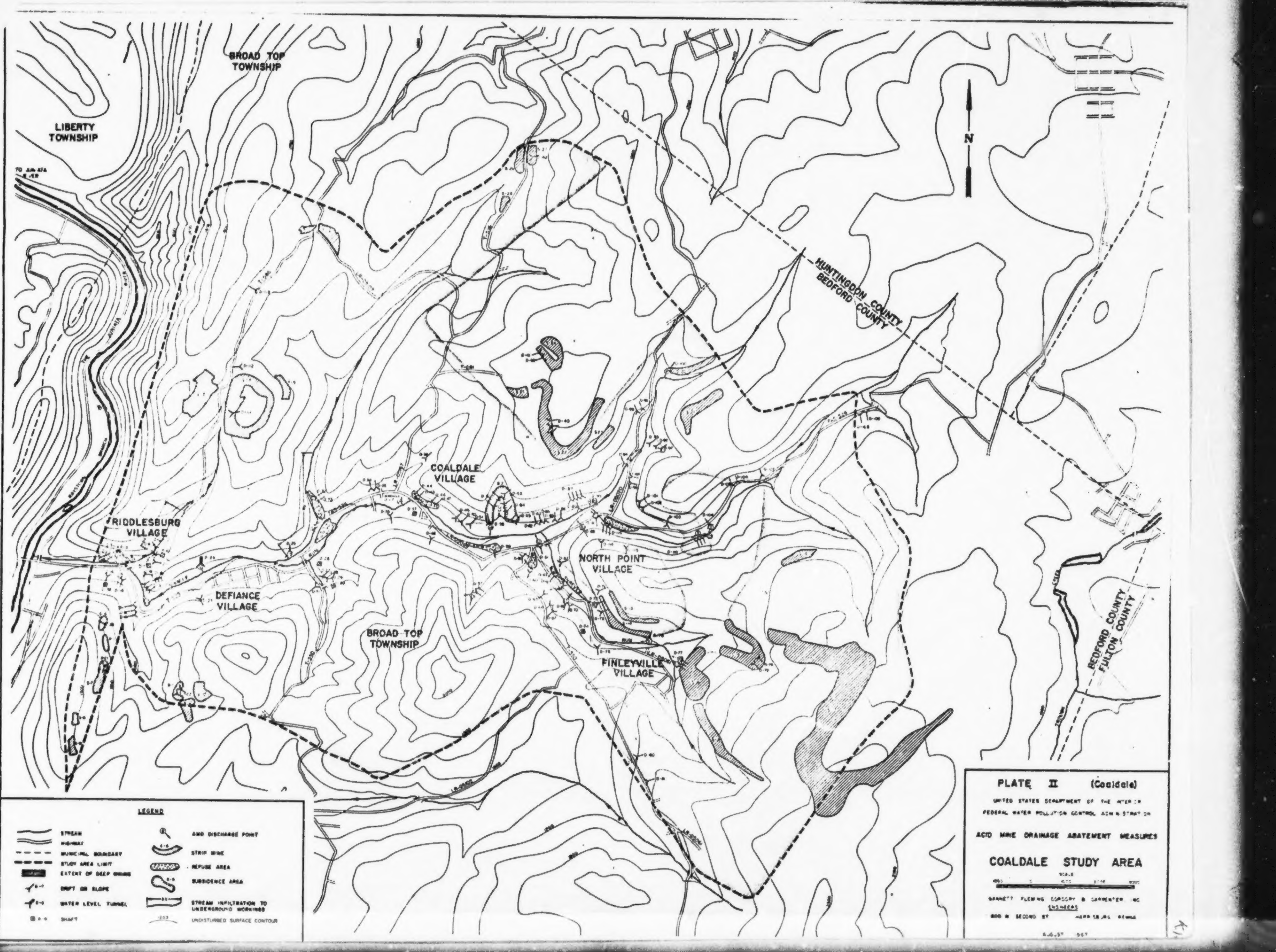

BROAD TOP TOWNSHIP
LIBERTY TOWNSHIP
TO JUNIATA RIVER
N
HUNTINGDON COUNTY
BEDFORD COUNTY
FULTON COUNTY
RIDDLESBURG VILLAGE
DEFIANCE VILLAGE
COALDALE VILLAGE
NORTH POINT VILLAGE
FINLEYVILLE VILLAGE
BROAD TOP TOWNSHIP
RAYSTOWN BRANCH
JUNIATA
LEGEND
STREAM
HIGHWAY
MUNICIPAL BOUNDARY
STUDY AREA LIMIT
EXTENT OF DEEP MINING
DRIFT OR SLOPE
WATER LEVEL TUNNEL
SHAFT
AMD DISCHARGE POINT
STRIP MINE
REFUSE AREA
SUBSIDENCE AREA
STREAM INFILTRATION TO UNDERGROUND WORKINGS
UNDISTURBED SURFACE CONTOUR
SCALE

PLATE II (Coaldale)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

COALDALE STUDY AREA

GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.

AUGUST 1967

K1

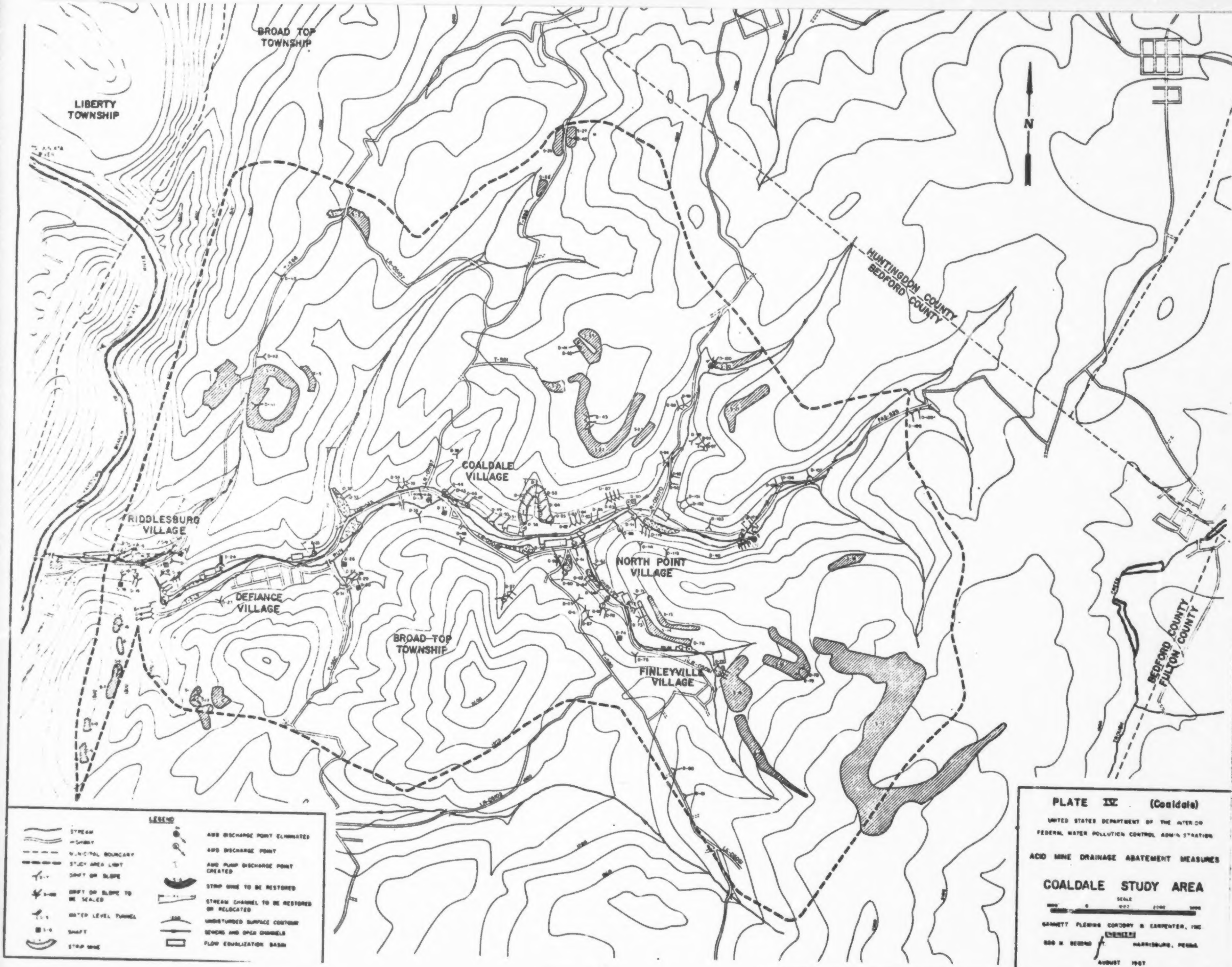

BROAD TOP TOWNSHIP
LIBERTY TOWNSHIP
N
HUNTINGDON COUNTY
BEDFORD COUNTY
BEDFORD COUNTY
FULTON COUNTY
COALDALE VILLAGE
RIDDLESBURG VILLAGE
NORTH POINT VILLAGE
DEFIANCE VILLAGE
BROAD-TOP TOWNSHIP
FINLEYVILLE VILLAGE
T-581
LEGEND
STREAM
HIGHWAY
MUNICIPAL BOUNDARY
STUDY AREA LIMIT
DRIFT OR SLOPE
DRIFT OR SLOPE TO BE SEALED
WATER LEVEL TUNNEL
SHAFT
STRIP MINE
AMD DISCHARGE POINT ELIMINATED
AMD DISCHARGE POINT
AMD PUMP DISCHARGE POINT CREATED
STRIP MINE TO BE RESTORED
STREAM CHANNEL TO BE RESTORED OR RELOCATED
UNDISTURBED SURFACE CONTOUR
SEWERS AND OPEN CHANNELS
FLOW EQUALIZATION BASIN
SCALE

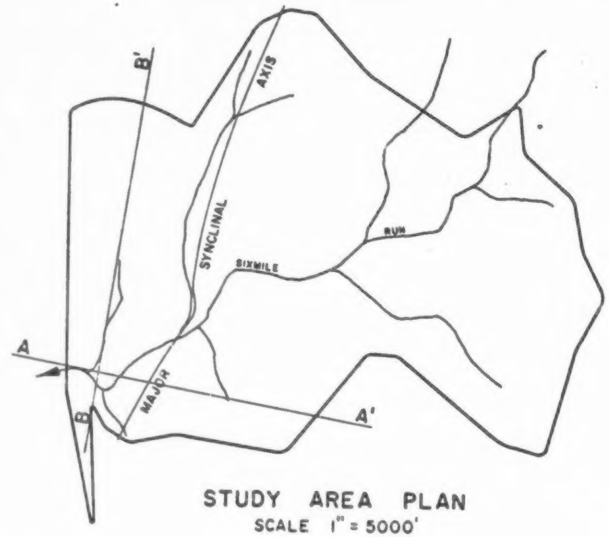
PLATE IV (Coaldale)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

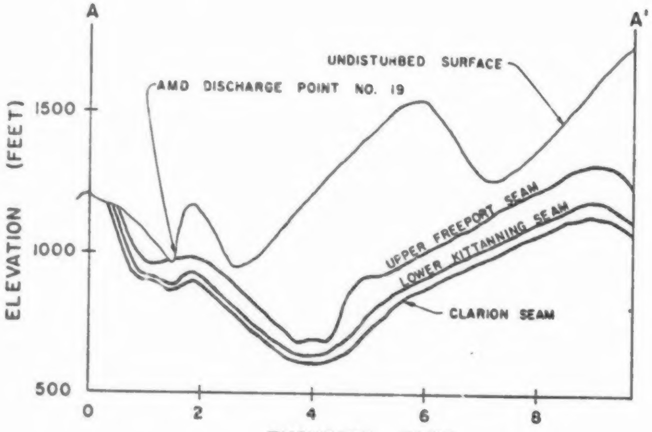
ACID MINE DRAINAGE ABATEMENT MEASURES

COALDALE STUDY AREA

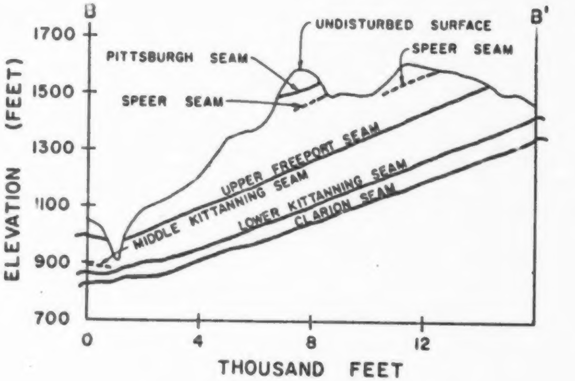
GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.
AUGUST 1967


B'
AXIS
SYNCLINAL
SIXMILE
RUN
A
A'
B
MAJOR

STUDY AREA PLAN
SCALE 1" = 5000'


A
A'
UNDISTURBED SURFACE
AMD DISCHARGE POINT NO. 19
ELEVATION (FEET)
1500
1000
500
UPPER FREEPORT SEAM
LOWER KITTANNING SEAM
CLARION SEAM
0
2
4
6
8
THOUSAND FEET

SECTION A - A'


B
B'
UNDISTURBED SURFACE
PITTSBURGH SEAM
SPEER SEAM
SPEER SEAM
ELEVATION (FEET)
1700
1500
1300
1100
900
700
UPPER FREEPORT SEAM
MIDDLE KITTANNING SEAM
LOWER KITTANNING SEAM
CLARION SEAM
0
4
8
12
THOUSAND FEET

SECTION B - B'

NOTE

1. DASHED LINES INDICATE AREAS WHERE COAL MEASURES HAVE NOT BEEN PROVEN TO BE CONSISTENTLY PRESENT.

PLATE III (Coaldale)

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ACID MINE DRAINAGE ABATEMENT MEASURES

COALDALE COAL SEAMS

GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
600 N. SECOND ST. HARRISBURG, PENNA.

AUGUST 1967

EXHIBIT A (Winburne)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Deep Mine Entries

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-1	Shaft	Lower Kittanning	--	X	Filled, no underground workings exposed	2
D-2	Shaft	Lower Kittanning	--	X	Partially caved, underground workings exposed, stripped by S-6 (1)	11, 12
D-3	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	2
D-4	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed	2
D-5	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, partially flooded, AMD discharge point 2 (1)	2
D-6	Shaft	Lower Kittanning	--	X	Filled, no underground workings exposed	11, 12
D-7	Drift	Lower Kittanning	--	X	Open, underground workings exposed	11, 12
D-8	Drift	Upper Kittanning	--	X	Open, underground workings exposed	3, 4, 5, 6, 7

EXHIBIT A (Winburne Continued)
Page Two

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-9	Shaft	Lower Kittanning	--	X	Filled, no underground workings exposed	3, 4, 5, 6, 7
D-10	Drift	Lower Kittanning	--	X	Open, underground workings exposed, AMD discharge point 4 (1)	4
D-11	Drift	Lower Kittanning	--	X	Partially caved, underground workings exposed, AMD discharge point 11 (1)	11
D-12	Drift	Lower Kittanning	--	X	Caved, no underground workings exposed, AMD discharge point 12 (1)	12
D-13	Drift	Lower Kittanning	--	X	Sealed, no underground workings exposed, AMD discharge point 8 (1)	8
D-14	Drift	Lower Kittanning	--	X	Sealed, no underground workings exposed, AMD discharge point 9 (1)	9
D-15	Drift	Lower Kittanning	--	X	Caved, possibly sealed, no underground workings exposed	8, 9, 13
D-16	Drift	Lower Kittanning	--	X	Caved, possibly sealed, no underground workings exposed, AMD discharge point 13 (1)	13

Deep Mine Entry (1)	Type Of Entry	Coal Seam Mined	Current Status Of Mine		Physical Features Of Entry	MD Discharge Point With Which Entry Communicates (1)
			Active	Inactive		
D-17	Drift	Lower Kittanning	--	X	Caved, possibly sealed, no underground workings exposed, AMD discharge point 10 (1)	10
D-18	Drift	Lower Kittanning	--	X	Caved, possibly sealed, no underground workings exposed	10
D-19	Drift	Lower Kittanning	--	X	Caved, possibly sealed, no underground workings exposed	11, 12
D-20	Drift	Lower Kittanning	--	X	Caved, formerly sealed, no underground workings exposed, stripped by S-21 (1)	3, 4, 5, 6, 7
D-21	Drift	Brookville	X	--	Two entries, both open, underground workings exposed, under initial development	---

(1) Refer to Plate II (Winburne)

EXHIBIT D (Winburne)

United States Department of the Interior
Federal Water Pollution Control Administration

Acid Mine Drainage Abatement Measures

Description Of Strip Mines

Strip Mine (1)	Coal Seam Stripped	Current Status Of Mine		Affected Acreage	Strip Pit			Type Of Interconnection With Deep Mine Workings		MD Discharge Point With Which Strip Mine Communicates (1)
		Active	Inactive		Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	
S-1	Middle Kittanning	--	X	3.8	1,000	1,000	Contour	--	X	1, 2
S-2	Middle Kittanning	--	X	2.4	500	500	Contour	--	X	1
S-3	Middle Kittanning	--	X	2.8	600	600	Contour	--	X	1
S-4	Middle Kittanning and Upper Kittanning	X	--	116.7	9,600	670	None			
						5,370	Sloped to highwall			
						2,980	Pasture	--	X	1, 11, 12
						580	Contour			
S-5	Middle Kittanning	--	X	3.1	1,100	1,100	Sloped to highwall	--	X	1
S-6	Lower Kittanning	--	X	50.2	7,800	3,900	None			
						1,950	Sloped to highwall			
						1,950	Pasture	X	--	1, 11, 12
S-7	Middle Kittanning and Upper Kittanning	--	X	166.3	4,800	4,800	Contour	--	X	11, 12
S-8	Middle Kittanning	--	X	16.4	2,700	2,700	Sloped to highwall	--	X	2

EXHIBIT D (Winburne Continued)
Page Three

		Current Status Of Mine			Strip Pit			Type Of Interconnection With Deep Mine Workings		
Strip Mine (1)	Coal Seam Stripped	Active	Inactive	Affected Acreage	Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	MD Discharge Point With Which Strip Mine Communicates (1)
S-20	Lower Kittanning	--	X	16.6	1,700	1,700	Sloped to highwall	X	--	3, 4, 5, 6, 7
S-21	Lower Kittanning	--	X	14.5	2,100	2,100	Sloped to highwall	X	--	3, 4, 5, 6, 7

(1) Refer to Plate II (Winburne)

EXHIBIT D (Winburne Continued)
Page Two

Strip Mine (1)	Coal Seam Stripped	Current Status Of Mine		Affected Acreage	Strip Pit			Type Of Interconnection With Deep Mine Workings		MD Discharge Point With Which Strip Mine Communicates (1)
		Active	Inactive		Length (feet)	Length Backfilled (feet)	Type Of Backfill	Direct - Deep Mine Workings Visible	Indirect - Apparent Infiltration From Bottom Of Pit	
S-9	Upper Kittanning	--	X	113.5	6,000	3,600	Sloped to highwall			
						2,400	Contour	--	X	2, 3, 4, 5, 6, 7
S-10	Middle Kittanning and Lower Kittanning	--	X	44.9	4,700	4,700	Sloped to highwall	X	X	3, 4, 5, 6, 7
S-11	Upper Kittanning	X	--	13.6	1,500	Active	Partly backfilled to date	--	X	3, 4, 5, 6, 7
S-12	Middle Kittanning	X	--	8.7	1,500	Active	Partly backfilled to date	--	X	3, 4, 5, 6, 7
S-13	Lower Kittanning	--	X	10.8	2,300	0	None	X	--	3, 4, 5, 6, 7
S-14	Middle Kittanning	--	X	20.4	1,500	1,500	Contour	--	X	3, 4, 5, 6, 7
S-15	Middle Kittanning	--	X	62.7	4,200	4,200	Contour	--	X	3, 4, 5, 6, 7
S-16	Middle Kittanning	--	X	33.8	2,400	2,400	Contour	--	X	3, 4, 5, 6, 7
S-17	Middle Kittanning	--	X	38.8	2,800	2,800	Contour	--	X	3, 4, 5, 6, 7
S-18	Middle Kittanning	--	X	18.6	4,600	4,600	Contour	--	X	3, 4, 5, 6, 7
S-19	Middle Kittanning	--	X	11.4	1,300	1,300	Contour	--	X	3, 4, 5, 6, 7